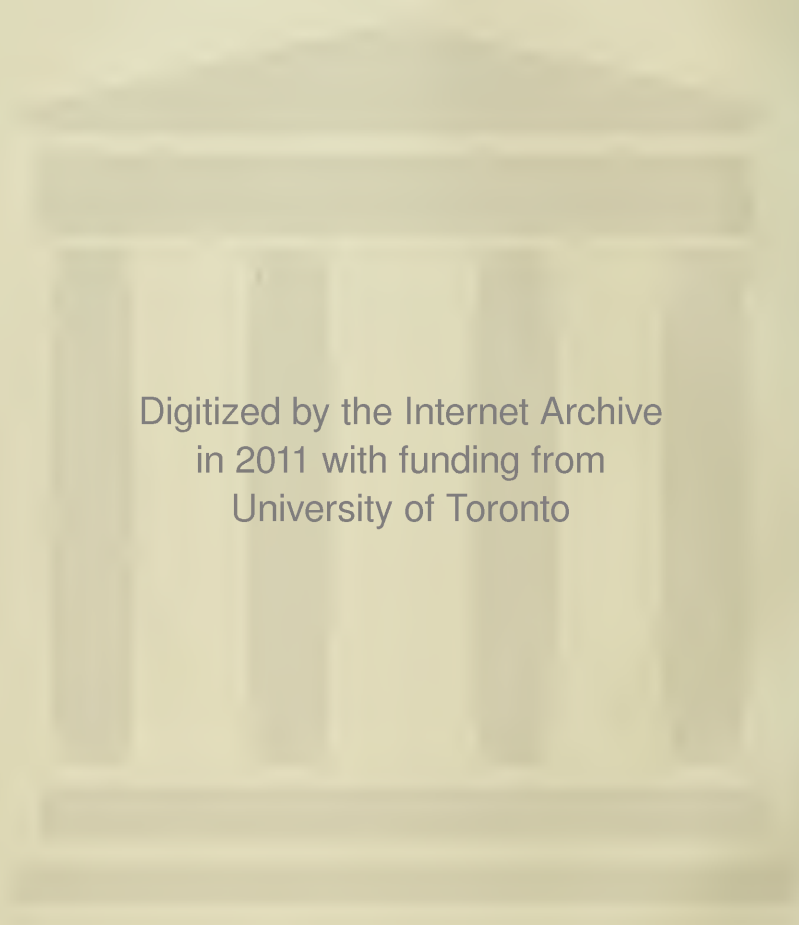


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VOLUME II, 1923



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BELL TELEPHONE QUARTERLY

VOLUME II, 1923

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BELL TELEPHONE QUARTERLY

A MEDIUM OF SUGGESTION AND A RECORD OF PROGRESS

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Vol. II

JANUARY, 1923

No. 1

A National Telephone Service

*From the Address of Mr. H. B. Thayer at the Thirty-
Fourth Annual Convention of the National Railway
and Utilities Commissioners, in Detroit, Michigan,
on November 15, 1922*

THE telephone business is a very young business. The first man who ever spoke over the telephone was living when I received your invitation to come here. The first man who ever heard a spoken word over the telephone line is still living. Its history has not acquired the obscurity of a remote past. A large part of that history in this country has been the history of the Bell organization.

From the very beginning a general plan has governed the policies of that organization which appears in its records and publications. Beginning in 1878 and before there was a telephone exchange in existence, Professor Bell's vision of the future was given in a statement to intending investors. He said:

"It is conceivable that cables of telephone wires could be laid underground, or suspended overhead, communicating by branch wires with private dwellings, country houses, shops, manufactories, etc., etc.—uniting them through the main cable with a central office where the wire could be connected as desired, establishing direct communication between any two places in the city. Such a plan as this, though impracticable at the present moment, will, I firmly believe, be the outcome of

the introduction of the telephone to the public. Not only so, but I believe in the future wires will unite the head offices in different cities, and a man in one part of the country may communicate by word of mouth with another in a distant part.

"I am aware that such ideas may appear to you Utopian and out of place, for we are met together for the purpose of discussing, not the future of the telephone, but its present.

"Believing, however, as I do that such a scheme will be the ultimate result of the telephone to the public, I will impress upon you all the advisability of keeping this end in view, that all present arrangements of the telephone may be eventually realized in this grand system."

If we analyze the early contract relations of The American Bell Telephone Company with the operating telephone companies which were its licensees and with the Western Electric Manufacturing Company, it becomes very apparent that they were based upon the assumption that its function was intended to be to provide a national telephone service. The company undertook forty years ago in these contracts to provide not only instruments but also a system of inter-communication between territories and to perform certain general services necessarily going with the development and management of a national system.

Again, the charter of The American Telephone and Telegraph Company taken out in March, 1885, shows that the company had in mind the establishment of a national service.

"The general route of the lines of this association, in addition to those hereinbefore described or designated, will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said State, and in each and every other of the United States, and in Canada and Mexico; and each and every of said cities, towns and places is to be connected with each and every other city, town or place in said States and Countries, and also by cable and other appropriate means with the rest of the known world, as may hereafter become necessary or desirable."

The purpose consistently followed through has been the creation of a national as distinguished from a sectional service.

Now let us think for a moment of how this country of ours differs from any other in the world. It covers an immense area, and but one language, comparatively free from dialects, is generally spoken. In government, it is a confederation of states, but our state boundaries are no barriers to commerce. There are no customs frontiers between the states. Contrary to the case of most other countries, it is the exception here when a man lives where his father or grandfather lived, and, I think, we could almost say that it is the exception when a man lives in the same state as the one in which his grandfather lived. This has been a nation of pioneers and colonists with the result that more than in any other country families are separated, so that, more than any other area in the world of similar size, it is one country, one people with far-reaching commercial and domestic relations. It follows that such a nation must have a complete telephone service covering the whole country: a service that has no narrower boundaries than the boundaries of the nation.

A national service can exist only through an organization which provides for a uniform policy and coordinated action. Uniformity of policy and cooperation comes to the Bell System through contract relations and community of ownership. The American Telephone and Telegraph Company owns directly or indirectly all of the voting stock of 14 associated companies, 78 per cent. of 9 others, and 31.5 per cent. of two others. The associated companies are responsible for telephone service in 5,848 communities and operate about 9,000,000 stations out of a total in the country of about 14,000,000. There is no autocratic control of the system. Its government is more like that of a republic. The policies and problems are carefully considered in view of the local conditions and under nation-wide conditions. They are discussed in common by those in the business having only nation-wide responsibilities and by those having also direct local responsibilities. When the conclusions are reached, they are the

conclusions of the Bell System. The policies established become the policies of the Bell System. In operation the associated companies are autonomous. In the organization of each associated company, the plan is to centralize as little as possible except in the establishment of policies and methods—to leave in the organization of each community the greatest amount of authority and responsibility for operation—to get the greatest economy and efficiency and satisfaction to the public, unhampered by any unnecessary reference to higher officials in the company.

A national telephone system could not be embraced in one corporation on account of the wide variation in corporation laws in different states. That being the case, in structure it is necessarily an organization of corporations, one of them exercising certain general functions for the benefit of the others.

Its history proves that in the operation of this organization, all other considerations have been subordinated to the development and improvement of its public service. Its program has been one of attempted foresight and anticipation of public requirements extending through all of the necessary steps—construction and maintenance of a sound financial structure the first essential to service, continual study of the future as to requirements and possibilities of meeting them, construction of adequate plant, and the maintenance of an adequate personnel.

The road by which the Bell System has progressed has not been like a city street where the traveller could find on either side supplies suited to all his requirements. The journey has been more like blazing a trail through the wilderness. You will recall that when the telephone was new, the commercial and domestic uses of electricity were limited to the simplest form of the telegraph and electric bells. Every telegraph operator knew as much about useful applications of electricity as the college professor.

A National Telephone Service

Let me give you a picture of the conditions by reading to you extracts from the recommendation for the building of the first commercial long distance line:

"May 12, 1885.

"The successful operation of the experimental circuit between New York and Boston has demonstrated that the telephone is a practical instrument for transmitting messages over long distances. * * *

"There are, however, a number of mechanical, electrical and financial problems still to be solved before that success can be achieved. * * *

"Highway lines of the size and character required for this work have never before been attempted. * * *

"The telephone seems to require a non-magnetic material in the line. Copper is the only available metal, and its use * * * is still experimental. The results, so far, are highly satisfactory, but only time and experience will determine its lasting qualities and the best methods for its manufacture and use.

"We know that a one-metallic circuit can be operated between New York and Boston, but we do not know that additional parallel circuits can be successfully worked; we have reason to fear that they cannot be if constructed in the ordinary way.

"To run a number of circuits between and into large cities involves the use of both aerial, underground and submarine cables to a very large extent. There seems to be a wide diversity in the opinions of electricians and manufacturers both as to the practicability of working through long cables and as to the size of conductors, nature and thickness of insulation, etc., which will secure the best attainable results. * * *

"The switchboards now in use are all planned for single-grounded circuits, and it will be necessary to arrange special apparatus for our circuits.

"It will be for many reasons desirable to introduce at the outset of our long distance business, a transmitter adapted in qualities and form to the requirements of this service, and to know as definitely as possible what kind and amount of battery will give the best results. * * *"

Problems were so far solved as to make possible the building and opening of the first commercial line which was built from New York to Philadelphia. Problems were subsequently solved which made it possible to carry a line from New York to Boston and then one to Chicago and then to carry it on to Denver and then to the Pacific coast.

After the sleet storms of last winter telephone conversation was carried on between Boston and Pittsburgh through cables. It was only by the solution years before of very difficult problems that that was made possible.

By the growth of cities and the increase in the use of the telephone the number of stations within the limits of a single city has mounted in several cases to over a hundred thousand and in one case to over a million, and the number of central offices within a city to over one hundred. Under one roof as many as 20,000 lines are switched. Some central offices are now planned for more than double that number. The accomplishment of these results with a continually improving service has presented problems.

As other lines of electrical work developed—electric light and power and heating, transportation—it has often happened when our people have come to a decision as to a necessary improvement in our art, that we have found that in one of the other arts or in a college laboratory or in the telephone business not controlled by us, inventions have been made and patents have been taken out, of which some claims might be interpreted in a way to interfere with our future progress, or covering inventions which might be of value in operation. We have undertaken to provide a free path for the development of the business, and that has involved the expenditure of millions in the acquisition of patent rights or licenses from others, in addition to the millions that we have had to expend ourselves on development, research and experiment.

It was in line with that same policy of providing a free path in which progress would be unhampered that in the early days we made the manufacturing arrangement with the Western Electric Company. In other public services the manufacturers make what they think is needed, and they control the patents upon their output. The Western Electric Company makes what we know that we need, and we control the patents.

As I have said before, we have gone beyond the point of having a purpose to establish a national service. There is a national service. Its maintenance is a responsibility—yours and ours. The responsibility upon us covers extensions into fields wherever population develops. It does not involve, to my mind, extension of direct operation by us into the fields now served by others, nor does such extension seem to me to be desirable except when greater efficiency or economy or better service point clearly to such a move. It does involve connection with the companies serving such fields. There are 9,290 connecting companies. In a few of these the Associated Companies have a direct financial interest. In the most of them they do not. The relation between the associated companies and the connecting companies is mutually helpful, and the tendency is all in the direction of standardization on the things which make for good service. They are a very important part of the national service, serving over 4,500,000 stations.

In a few localities two companies are attempting to serve the same community. That means that neither serves it wholly. It must mean either partial service or two charges for the telephone users in that community. The public and you, gentlemen of the commissions, have repeatedly indicated your belief that such a condition is economically unsound and against the public interest. Whenever the desire of the public that such a condition shall be eliminated shall be expressed through you, the public's representatives, we shall feel under an obligation to do our part with your approval, in endeavoring to remedy that condition.

The policy of the system is very simple. The fact that we are the servant of the public is fundamental. We must satisfy and please our master. All of our efforts must be directed toward what will produce that result. We must give good service. The only test we can apply to any practice or project under consideration is to resolve the question as to whether it is for the betterment of the service. We believe that the public wants the best service

that we can give, that it is satisfied to pay a fair price for good service and does not want, in the settled communities, anything less than a dependable service at any price.

From the fact that the sender of a telephone message is himself waiting when there is a delay in furnishing service—that he is therefore personally experiencing an inconvenience—he is more critical of bad telephone service than of any other bad service, or putting it conversely, the public expects a higher standard of service from the telephone company than from anyone else, and it is important that it should be better than any other service because it is the public's reliance more than any other in times of commercial or domestic emergency.

To give that kind of service we must pay wages which will attract and hold a picked lot of people, and we must stimulate in them an enthusiasm for the business. They must know what we are trying to do and be in sympathy with it. We consider it as much a part of our work to foster a spirit of service among the people in our business as it is to furnish poles and wire.

There is no organization for giving telephone service elsewhere which very closely resembles the one I have been describing. It is a purely American institution. Before we attempt to decide whether it is a good institution or the best for its purpose, let us see what it has accomplished. There is a development of one telephone to every eight persons in this country, so distributed and inter-connected that a telephone is practically within reach of every human habitation or place of business in the country for communication with any other, every hour of every day and night. Nowhere else does such a condition exist. Europe has over four times the population of the United States; it has less than half the number of telephones. Great Britain has fewer telephones than Greater New York. Germany has only three telephones per 100 inhabitants. France has about one per 100, having less telephones than the state of Michigan, though having 10 times the population. Detroit has more

telephones than Brussels, Liverpool, Budapest, Rome, Amsterdam and Marseilles combined, with about one-fifth of the population. Except in the more important places in foreign countries, the telephone service is not a twenty-four-hour service. In Switzerland, in some ways an example of the best service in Europe, on week days 96 per cent. of the telephone exchanges are closed at 8:30 P. M.; 23 per cent. are open from 7:45 A. M. until 12:15, then close an hour and three-quarters, open again until 6 P. M., close an hour and a half, and finally open at 7:30 P. M. for half an hour, when the shutters are put up for the night, while on Sunday and holidays the service is even more restricted. The difficulties of telephone service increase in more than direct ratio with the development. There is no public which exacts as high a standard of service as the American public. I believe that my statement will be unquestioned, that the difficulties in the way of giving a satisfactory telephone service are for the above reasons greater by far in this country than anywhere else. Yet I am confident that nowhere else is the public so near to satisfaction with its telephone as here.

With the potentiality for connection with a continually increasing percentage of a continually increasing population, the value of service has continually increased.

If we take the present value of the dollar, measuring it by what it will purchase at the present average wholesale price of commodities, the average charge for telephone service is more than 10 per cent. lower than in 1914, although using that same present value of the dollar we pay over 15 per cent. higher wages than we did then, so that I am justified in saying that although we are paying more for material and more for labor, we are giving more value in service, for less real money, now than before the war.

Since the beginning of this Century, the population of this country has increased 45 per cent. The investment in railroad plant and equipment has increased 135 per cent. During that period we have been obliged to increase the investment of the Bell telephone plant 960

per cent. to take care of an increase in the number of telephones of 1240 per cent.

The purpose, methods and policies I have described have produced the best service, the greatest development and the best satisfied public in the world. That is not my opinion alone. It is the general opinion here and abroad. I assume that it is your opinion. Now then, when we consider any change, we must have it in mind that it is a change from what has produced the best known result in its line of work. We do not rest on that result. We are looking for something better than the best. But if we, all of us, you of the regulation and we of the management, should abandon or displace proven methods for visions, we could not escape a very definite responsibility to the nation.

There is a strictly community service furnished by the telephone, and a state service, and an inter-state service. The same terminal stations used in the community service are used or usable in the state and inter-state services; other parts of the plant and the service of personnel used in the community service are used or usable in state and inter-state service.

When it comes to the regulation of charges, it is sometimes by communities, sometimes by states and sometimes by the Inter-state Commerce Commission, according to the laws of the states and of the nation as they exist.

Except with reference to inter-state toll rates, the regulation is under state laws and generally by state commissions, so that you, gentlemen of the state commissions, are confronted with the problem of considering the value to your constituents of development outside your states, and the cost of service to your public, part of which service is rendered beyond your jurisdiction and, furthermore, some of the companies serving you perform some of their functions outside the state and have other functions performed for them by another company outside your jurisdiction. These difficulties come out of the fact that your jurisdiction is necessarily limited to your states, while telephone service cannot be limited by state

boundaries. They introduce into the expenditures of these companies, subject to your regulation, certain general charges covering necessary services of great value, but of such a nature that precise values cannot be easily ascertained, so that the charges can be verified only as less than value received.

While you are circumscribed to a state point of view, if in arriving at your conclusions, you think it advisable to study the financial results of the national system, it is possible for you to do so. Sworn statements of each company forming a part of the national operating organization, including The American Telephone and Telegraph Company, are matters of public record filed with the states and with the Inter-state Commerce Commission, and a compilation of those statements, eliminating only inter-company transactions so as to present the operations of the organization as a whole, is presented annually in the report of The American Telephone and Telegraph Company.

The license contract between The American Telephone and Telegraph Company and the associated companies was intended to afford, and has afforded, the basis absolutely essential to a national telephone system. Aside from all questions of economy and efficiency, a national universal service could not be provided at all by a large number of uncoordinated local units. As a part of its plan, the contract provides in general terms for such services to the associated companies as can be most economically and efficiently rendered by one central agency. It includes the obligation on the part of the American Company to construct, operate and extend the long distance lines connecting the various companies into an harmonious national operating unit.

The purpose of this contract is to provide a national universal service which shall be as efficient and economical and of as high standard as is attainable. It provides that all services essential to that end shall be rendered to the associated companies for a compensation adjusted upon an equitable basis.

The license contract is usually between two companies in which there is a community of interest, although when the contracts were originally made this was not true, the parties then being entirely independent of each other and dealing at arm's length. The present relations between the companies suggest that you closely scrutinize these contracts. The American Telephone and Telegraph Company does not object to such scrutiny; on the contrary, it is constantly inviting it. Contracts made between corporations subject to a common control are not illegal. If close scrutiny develops the fact that they are fair, they must be accepted. It is only where such scrutiny shows them to be so unfair as to demonstrate an abuse of the relations between the parties to the material injury of one of them that the injured party may complain. Concretely, whether any license contract of the Bell System is unfair to the licensee or whether its effect is to work serious injury to the licensee, is a legitimate matter of inquiry, but the inquiry is as to the effect of the contract upon the licensee, not as to its effect upon the American Company; and if such inquiry develops that the contract is beneficial to the licensee, that the benefits received by the licensee under it not only exceed the payments which it makes but are to be evaluated at many times the amount of such payments, then the contract stands upon the same basis as any other contract.

Of whatever the Bell System has accomplished in the way of realization of its ideal of a national service or in the way of improvements in the service or economies in the service, the public is the beneficiary. The license contract arrangement which has made this all possible has passed the essential test. It has been of far greater value to the public than what the public has paid on account of it.

The better case a man has, the more it is to his interest that the one passing upon the merits of his case should be well informed as to his case. Obviously, a commission keeping in close touch with the operations and results of operations of a public service will be better informed than

any agency which only occasionally attempts to inform itself on the occasions when a change in the charges to the public is to be considered. That is why we have consistently advocated regulation by commissions. In 1913 Mr. Vail made this statement:

“We believe in and were the first to advocate state or government control and regulation of public utilities; that this control or regulation should be by permanent quasi-judicial bodies, acting after thorough investigation and governed by the equities of each case; and that this control or regulation, beyond requiring the greatest efficiency and economy, should not interfere with management or operation. We believe that these bodies, if they are to be permanent, effective and of public benefit, should be thoroughly representative; they should be of such character and should so conduct their investigations and deliberations as to command such respect from both the public and the corporations that both will without question accept their conclusions.”

We believe that the best results for the service and, therefore, for the public will be attained by a relation of confidence and cooperation between the commissions and ourselves. We intend to deserve the confidence of the commissions by the utmost frankness and straightforwardness in our dealings with them, and we hope for a time when the commissions will be kept so well informed continually as to our operations and results and problems and necessities that the great expense of occasional investigations may be saved. We are making systematic efforts to widen the ownership in the Bell System because people will inform themselves and their neighbors about the operations of an institution in which they are partners, and we welcome every opportunity to increase the knowledge of our operations among telephone users. No institution is more publicly owned. Its plant has been built out of savings of the people. It is being extended out of such savings. It is the people's institution more than any other.

From the character of its ownership and because a large proportion of the people of this country depend upon the Bell System for their telephone service, its management and operation is a trust and obligation to the public

which must be fulfilled to the satisfaction of the public. It will not be completely fulfilled until rates are low enough to impel everyone to have a telephone in his own residence or office who ought to have one for his own convenience or the convenience of the country. Consistent with this belief, I feel safe in saying that the desirability of lower rates is more in our minds than in the minds of the public and at least as much as in the minds of the commissioners.

The value of the service to the large user is so much in excess of its cost and so much increased by a wider extension of the service, that I am firmly of the opinion that whenever a reduction is possible it should be in the charges to the small user. It seems proper to me that commissions should take value into consideration in the making of rate schedules and I think that they should take it into consideration in comparing costs of service.

The interest of the public and our interest are identical in the direction of greatest value which includes greatest extension of the service at fair rates. Sound, efficient and economical regulation involves, therefore, cooperation between the commissions and our companies to produce that result. It involves, when the time comes for a change of rates, a study between them as to what increase or decrease in revenue is indicated, followed by another study on rates with a view to effecting the necessary change in such a way as to make the service available to the greatest number.

I can imagine a commission, in fulfilling its obligations, calling to account a company not sufficiently alert as to its conditions and instructing it that its rates must be increased so that its service to the public may not be in danger. There have been cases where that kind of caution was necessary.

Commission regulation, on the whole, has been satisfactory. We have intended to present our views to them fairly, completely and in a straightforward way. We haven't always reached our standards. Commissions as kept have manifestly intended to be judicial and fair. operation, they have temporized. They have during the

past three or four years passed through a very difficult period in which, in order to maintain service of the utilities, rate changes have been advances and not decreases.

Since the beginning of the war our cost of labor per station per annum has increased over 100 per cent.; maintenance material over 40 per cent.; taxes over 106 per cent.; The Bell System is being taxed now at the rate of over \$40,000,000 per year. It will be a long time, if ever, before these increases in cost fade away. Other expenses, including management, four and a half per cent. payments, depreciation, etc., in that same period have increased between two and a half per cent. and three per cent.

Since the termination of the period of federal control, the associated companies of the Bell System have been before state commissions and other regulatory bodies in 205 separate proceedings, some of them involving the change in a rate in a single city, some of them involving changes in rates in practically all the cities of a state. The decisions of the commissions have been accepted in all but 20 cases, although in some of those cases accepted it has been felt by the companies that they were not getting all to which they were either legally or fairly entitled. If there seemed even a possibility of going on without detriment to the maintenance and extension of the service they accepted the decisions. When we have appealed from the commissions to the courts it has been with reluctance and because we believed it our duty in order to preserve and extend the service. In the 20 cases which have been taken into the courts, decisions have been rendered in 11. In all but one of the 11 our contentions have been upheld.

Take the Bell System as a whole; it has an investment of about two billions of dollars, between two and three hundred thousand employees—serves about nine millions of customers directly and is responsible for returns to four or five hundred thousand stock and security holders. That puts it among the large business enterprises of the world. I do not mention this as a glorification, but only

to call attention to this advantage to the public in dealing with such an institution. We are about as conspicuous as a pyramid in a desert. We cannot afford at the risk of losing any part of public approval to vary a hair from the course toward the objective which we are convinced is the only objective which the public will finally approve. And that is the best and broadest service which can be given at fair rates. We must have its approval all along the course which means that none of our methods of operation or of our rules of conduct must fall below the highest standards.

I have been talking about the Bell System of today, but we are all looking forward to the task of tomorrow, and if we are to meet our increasing obligations, we must have the confidence and cooperation of the public and of you, its representatives.

We are studying the probable telephone requirements for the next five, ten and fifteen years; we are considering the new capital that will be required to meet the demanded growth; we have men studying the innumerable inventions and technical improvements without which we could not reach our objective. We have to think in big figures,—big figures for labor, material and financial resources, for if we did not, we would be overwhelmed by the increasing public demands.

If we can make you see our objective as we see it, if we can make the picture of the future live in your minds as it does in ours, I am confident that you will see it as an objective of far-reaching national importance, which commands the utmost seriousness on your part, and on our part, and that from that seriousness should come such cooperation as will bring the results which the country demands.

H. B. THAYER.

NOTE: Mr. Frank Gill, President of the British Institute of Electrical Engineers, in his recent inaugural address, gave a comprehensive review of the progress of telephony and explained at some length the effect of

recent developments upon long distance communication. Of particular interest in connection with the address of Mr. Thayer is the editorial comment of the *Electrical Review* of London, which, after a synopsis of some of Mr. Gill's technical statements as to loading coils, telephone repeaters and "carrier" channels, continues as follows:

"But all these refinements are subject to one essential condition—that the lines to which they are applied shall be suitable in all respects and at all times for the application of the repeating and multiplying devices above mentioned; and that involves as an imperative necessity *unity of control*. This, in fact, is the keynote of Mr. Gill's address. After explaining how the indispensable unity of control obtains in the United States, in spite of the existence of 10,000 telephone companies, he shows that in Europe the conditions are at present fundamentally different—the very antithesis of unity. Nevertheless facility of intercommunication between town and town throughout the European area is of immense importance. No fewer than 4,000,000 long-distance calls are originated at New York per annum; the United States has found the telephone indispensable to the speedy transaction of commercial affairs—and Mr. Gill asks: Why should not Europe share that convenience?

"Thus he arrives at the climax of his thesis—the astounding proposition that Europe should, in effect, be treated as one country for telephonic purposes; that either a single company should handle all the long-distance traffic, or the various Governments should form a Commission for the same purpose. He is even ready to submit a plan for the consideration of the authorities concerned, by which the desired result could be brought about."

Engineering the Long Lines

ONE of the obligations of the American Telephone and Telegraph Company is to provide the necessary plant and handle the telephone service connecting the territories of the licensee companies. In the organization of the Bell System this plant is provided and this service is handled by the Long Lines Department of the American Telephone and Telegraph Company. Since the first construction plans were made and the first pole was set in 1885 as the start of a line between New York and Philadelphia, the engineering plans have been under a uniform policy and along lines consistent with the terms of the various license contracts. Plans for many years in the future have been worked out along these same lines.

The purpose of this article is to outline a few of the engineering features involved in the plans for the construction of the present plant, and proposed extensions. While some of the engineering features described have a particular application to the Long Lines plant, others are also being extensively applied in other parts of the Bell System and elsewhere.

The book investment in Long Lines plant and equipment now exceeds \$100,000,000, and is rapidly increasing. Estimates indicate that within the next five year period the investment will approximate \$150,000,000. Some facilities are obtained on a rental basis, as, for example, space in buildings. Over 500,000 miles of telephone circuits are in service, and nearly 100,000 messages are being handled each business day. The growth in telephone traffic for the past twenty year period is indicated in a general way by the curve in Figure 1. The average increase for each year over the preceding year throughout this period has been ten per cent. As is well known, the length of haul has steadily increased and is still increasing, so that in considering this development of long distance service it is necessary to take into account both the number of messages and distances involved.

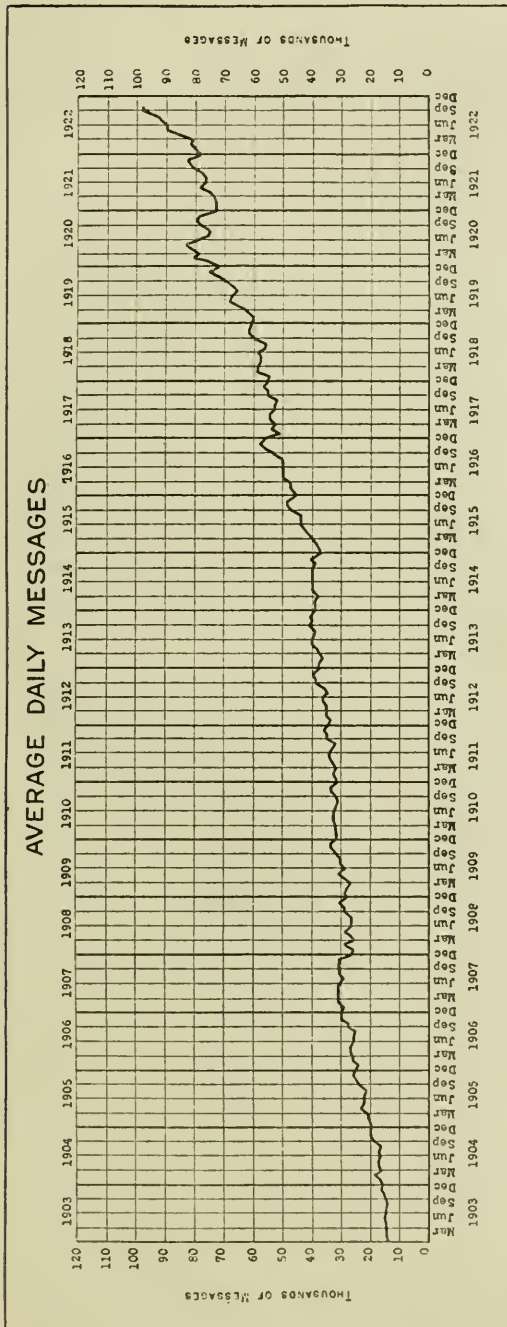


FIG. 1

The above facts are mentioned here, simply to illustrate in a general way the type of engineering problems involved and the fact that with the service requirements constantly increasing there is a corresponding increase in problems to be solved. Essentially, these constitute the problem of inter-connecting cities and territories, as might be illustrated in a general way by reference to such systems as trunk line railroads, steamship lines or national highways. However, some fundamental differences exist in that a complete national telephone service involves the direct connection of the trunk line telephone plant to the plant provided for local service, thus

making available to the users of the service a complete line for direct communication from subscriber's station to subscriber's station. All plans must be made with this purpose in mind.

POLE LINES

In the Long Lines plant there are now more than one and one-quarter million poles used for supporting wire or cables. Three kinds of timber are now used for new work. These are creosoted pine, chestnut and cedar, the choice depending on which is the most economical after considering all factors involved in a specific job. In general, chestnut and cedar poles, up to the present time, have been used untreated, but the present practice is to use butt-treated poles, and the use of untreated timber is the exception. It has been found that this practice is justified in this type of plant from the standpoints of cost and service results.

As a part of the constant endeavor to furnish the best possible service, the pole lines are maintained at high standards of strength. A detailed inspection in 1922 of every tenth pole in New York, in connection with an appraisal, showed that the average physical condition of the pole lines in that state was about eighty per cent. To maintain these standards, inspections are made at frequent intervals, usually every three years, and any necessary work is done to bring the condition of the lines up to the requirements of the standard specifications.

While many sizes and lengths of poles are used, we find most of the lines carrying aerial wires built with Class A, B or C poles, 25, 30 or 35 feet in length and spaced at 130-foot intervals. Fir or creosoted pine cross-arms ten feet long and equipped with locust pins for ten wires are used in most sections, and the crossarms are normally spaced two feet apart. This general type of plant is familiar to many telephone people, and it is frequently possible to identify these long distance lines by their uniform and characteristic construction.

AERIAL WIRE

For telephone purposes, hard-drawn copper wire is used exclusively. On some of the older lines one No. 6 B.W.G. iron wire was strung and supported on pins and insulators attached directly to the pole tops and used for telegraph purposes. As this iron wire has deteriorated to the point requiring replacement in various sections, it has generally been dismantled.

The copper wires are of two sizes—No. 8 Birmingham wire gauge, weighing 435 pounds per wire mile, and No. 12 New British standard gauge weighing 173 pounds per wire mile. It is interesting to note that no change in the practice originally established for the Long Lines Department with respect to sizes of hard-drawn copper wire for aerial line construction has been found necessary or advisable, although the matter has been considered at various times. However, the gauge most frequently used in this country for copper wire is the American wire gauge.

It is also an interesting fact that the original wire can still be utilized although many changes have been made in the types of service handled over the wires since they were installed and many re-arrangements of them have been necessary, as for example, changes in types of transposition systems to obtain better results or phantom circuits, loading coils of one type installed on circuits to be replaced later with coils of another type and still later removed entirely. Under favorable conditions the life of copper wire is very great, and no appreciable deterioration can be detected in most of the wire. Therefore, the average life is determined principally by the effects of storms, which cause severe damage in some sections nearly every year, deterioration due to unusual conditions, such as the presence of gas or fumes from chemicals, and removal for right of way reasons or on account of paralleling cables making the continued use of some of the aerial wire no longer economical.

As far as practicable, the wire is transposed for phantom operation—the total aerial wire mileage being

over 525,000 miles, of which over 85 per cent is arranged for phantom operation. Loading coils are used extensively on aerial wire circuits to reduce transmission losses, and while they continue to be installed in those cases where necessary reductions in transmission losses can thus be most economically and satisfactorily obtained, they are also being removed from some aerial wire circuits to make them available for carrier current operation, and to obtain transmission of a better quality than can be furnished with loaded aerial wire circuits of the present standard type. For example, loading coils have been removed from the transcontinental group of circuits and from many circuits in the sections between New York, Chicago and St. Louis. The New York-Havana circuits have no loading coils connected to the aerial sections.

CABLES

The familiar types of aerial wire lines which have been used so extensively in the past are today the most efficient and economical types of construction for many conditions, and large amounts of wire are installed each year. However, in certain sections of the country and along certain routes the requirements for circuits are such that it is difficult to provide a sufficient number of pole lines at a reasonable cost, and for these sections cable has been used extensively. The cable type of plant has many important advantages as compared to aerial wire for many circuits in such sections, some of these being lower annual cost, greater reliability of service and greater flexibility.

The transmission problem involved in the design of long distance circuits in cables is more complicated than for the case of circuits made up of aerial wire, and the necessary equipment, such as telephone repeaters and other apparatus associated with such cable circuits is very much more extensive.

As is generally known, long underground cables have been in operation for a number of years, between Boston

and Washington, Chicago and Milwaukee, and in other sections. The older cables in such sections contain conductors varying from No. 16 A.W.G. to No. 10 A.W.G., and a full size cable of this type only provides about one hundred circuits. As estimates of traffic indicated that several cables would be required along these routes within a reasonable period of years, and as many of the sections traversed were well built up, it was found desirable to construct subways and place the cables entirely underground.

The development of telephone repeaters made it possible to use conductors of a smaller gauge, so that in long toll cables now being installed, the majority of the conductors are No. 19 A.W.G. with some No. 16 A.W.G. conductors, the latter being intended for use in relatively short circuits, while it is expected to use No. 19 gauge conductors in four-wire circuit combinations for distances up to at least one thousand miles. This type of cable provides 250 to 300 telephone circuits, if needed, and a smaller number of cables will be required along any one route than would be the case if it were still necessary to use the older types of cable.

This, in turn, makes it more economical in many sections to employ aerial construction except through built up areas, and aerial cable supported on poles 25 feet in length, is being generally used for the New York-Chicago cable. The section of this cable from New York to New Castle, Penna. is installed. Work on extensions is going on and it is expected that the cable will be in service, as far west as Cleveland, by July 1, 1923. It is proposed to complete the Chicago-South Bend section early in 1924, and this probably will be followed by the Cleveland-Toledo and Toledo-South Bend sections in order. It is probable, therefore, that the New York-Chicago cable will be completed throughout the entire distance about 1926.

As the different sections of toll cable are placed in service some open wire is dismantled immediately, and additional wire is to be dismantled later on. This dis-

mantling lightens the load on the pole lines, which, in turn, reduces the liability of storm damage, and greatly reduces the maintenance cost. It is necessary, in general, to construct new pole lines for these cables, and every effort is made to obtain permanent locations and rights of way. While permanent rights of way are important for all toll lines, they are even more necessary for long toll cables as future relocations must be kept at a minimum to economically maintain uniform loading coil spacing. The loading coils are spaced very accurately at regular intervals of about 6000 feet and the successful operation of the many telephone repeaters that it is necessary to use on these cable circuits is largely dependent on the continuous maintenance of this accurate spacing.

TELEPHONE REPEATERS

Many telephone repeaters are used in connection with aerial wire circuits, but a much larger number are used on cable circuits. Repeaters are located at different intervals on a circuit, depending upon the kind of facilities involved. For example, on non-loaded No. 8 B.W.G. circuits, repeaters are located at about 250 mile intervals, while on No. 19 gauge two-wire cable circuits they are located at intervals of about 50 miles. To provide the repeater stations along the toll cable routes many new buildings are needed. About 2500 telephone repeaters of all kinds are now in service in the plant of the Long Lines Department.

The use of telephone repeaters has introduced entirely new features in toll circuit design work. In a circuit without telephone repeaters, energy is introduced on the circuit at one point, the transmitting end, and a part of the same energy is received at the other end of the circuit. Where intermediate telephone repeaters are used the energy originating at a transmitter operates the first repeater it meets in its travel along the circuit. From the output side of this repeater there is delivered new energy to be sent on its way along the circuit until the

next repeater is met, where the operation just described is repeated, until finally the energy from the output side of the last repeater is sent on its way to the receiver at the terminal of the circuit.

In a circuit using intermediate telephone repeaters, and some circuits have as many as eight repeaters operated in tandem, it is necessary that they be properly spaced, taking into consideration both the available repeater station locations and the electrical characteristics of the circuit facilities. The energy levels at each repeater must be carefully predetermined, as it is important that the energy delivered to and by each be kept within proper limits; that is, too much energy must not be sent out from one repeater or it will cause "cross talk" in adjacent circuits, and, on the other hand, the energy must not be allowed to drop off so far that its magnitude at the input of a repeater is only about the same as that of the noise which happens to exist on the circuit, as this condition will result in the noise being amplified to an objectionable degree along with the amplification of the speech currents.

The matter of proper arrangement of repeaters in a single circuit as described above is only one of the important features which must be taken into consideration in the design of a network of long distance circuits, but it serves to illustrate that the problem is very decidedly one of considering each circuit and also groups of circuits as a whole at the time the design work is done, and similar centralized control is of equal or greater importance in the every day maintenance and operation, if satisfactory service is to be secured.

TELEGRAPH

Plant of the type provided by the Long Lines Department for the handling of long distance telephone service is utilized to furnish certain classes of telegraph service using simultaneously the same wires that are required for telephone purposes. Rapid as has been the growth of long distance telephone service, no less rapid has been the

development of this telegraph service. There are now 525,000 miles of telegraph circuits in operation, and service under special contracts is furnished to banks, brokers, press associations, packers and other commercial organizations. These telegraph circuits are also used in the operation and maintenance of the plant and for handling official telegraph business.

Morse's original telegraph used two wires and was only capable of transmitting in one direction at a time. This transmission was slow and the incoming signals were recorded in dots and dashes by a tape recorder. Contrasted with this we may have today one pair of copper wires carrying simultaneously one and one-half telephone circuits, two telegraph circuits of the more common direct current type using ground return and as many as ten carrier current telegraph circuits. Furthermore, each of these twelve telegraph circuits may be operated in both directions simultaneously by the ordinary duplex telegraph methods and if desired, by the use of printing telegraph apparatus, each may be made to print from one to four messages in each direction. A complete arrangement of this latter type is not now in regular use, but in many cases a single pair of wires is carrying one and one-half telephone and twelve telegraph circuits. Printing telegraph apparatus is operated on a part of the telegraph circuits but most circuits are manually operated. The quadruplex system has not been found practicable for use in the Long Line plant.

Telegraph service was first furnished by the Long Lines Department on wires used for telegraph only. This was followed in turn by the simplex system, which furnished one telephone and one telegraph circuit simultaneously, the composite system which added a second telegraph circuit for each pair of wires, and finally by the carrier current system, which has brought the number of telegraph circuits per pair of wires, where suitable conditions exist, up to a practicable total of twelve.

As the telegraph systems now in use on the open wire lines are not suitable for use on long, small gauge, loaded,

cable circuits, the recent extensive installation of this type of plant by the Long Lines Department has made desirable the use of still another telegraph system. This newly developed system is operated on the "metallic" basis, furnishing but one telegraph circuit per pair of wires, but these wires may also be used for telephone purposes. It is thought, however, that ample telegraph facilities will be available in the toll cables to meet all requirements along these routes for a long period, or until additional cables are needed for telephone purposes. Each of these circuits may be operated in both directions at the same time without interference to the telephone circuit carried on the same wires.

CARRIER CURRENT SYSTEMS

A recently developed system of telephony and telegraphy known as the "carrier current" system makes possible the provision of additional circuit facilities on certain classes of the existing wire plant. The operation of this system depends upon the use of comparatively high frequency alternating currents which can be transmitted over suitable circuits simultaneously with the more commonly used low frequency telephone and telegraph currents. Additional telephone or telegraph circuits as may be desired are thus obtained without detracting from the usefulness of the circuit for carrying at the same time what was formerly its regular load of telephone and telegraph business.

The Long Lines Department is making extensive use of this new system to provide additional facilities in sections where suitable plant is available for "carrier current" operation. The first carrier current telephone system to be placed in commercial service in this country provided four additional telephone circuits between Pittsburgh and Baltimore in 1918. From Baltimore the circuits were extended to Washington through the cables. Since that time four additional systems have been installed, furnishing a total of 8500 miles of telephone

circuits. Plans have been completed for extensions which will greatly increase this figure in the near future.

The first installation of carrier current telegraph equipment for commercial service was placed in operation between Harrisburg and Chicago early in 1920, providing ten Harrisburg-Chicago telegraph circuits which were extended from Harrisburg to New York on other available facilities. There are now in operation in the Long Lines Department a total of twelve carrier current telegraph systems providing 62,000 miles of telegraph circuits. These figures include telegraph facilities provided by the carrier current system from Harrisburg, Penna. westward along the transcontinental route.

EQUIPMENT

Switchboards, testboards and morseboards as well as many other kinds of equipment are used in the Long Lines plant. The switchboards are in general, standard toll sections equipped with such apparatus and circuits as the requirements of a particular office may determine. The testboards are designed to provide a common center for line and switchboard circuits and circuits connecting together such items of equipment as phantom sets, composite sets and composite ringers. Facilities are provided for quickly making layout changes in case of trouble and for locating such troubles as occur. The morseboards are designed to serve as terminals of telegraph operating equipment such as duplex sets, telegraph repeaters or carrier current telegraph channels, and also as a common center for telegraph circuits and loops to subscribers' offices. Equipment is provided to facilitate regular operation and rearrangements.

ORGANIZATION

The Long Lines Department is organized on a functional basis and the engineering work is assigned in about the same way as in other associated companies. The

Long Lines Engineering Department, which corresponds to the engineering department of an associated company, is located in New York City, and commercial engineering and traffic engineering are done by forces which are a part of the organizations of those two departments. In addition, engineering work is performed by the forces of five division plant engineers reporting to the division plant superintendents located at New York City, Philadelphia, Chicago, Atlanta and St. Louis, respectively. The commercial engineering work involves particularly the estimates of business to be expected and rate questions. Traffic engineering involves the determination of circuit and equipment facilities required on the basis of the Commercial Department's estimates of business.

In the Long Lines Engineering Department studies are made and fundamental or detailed plans are determined upon for the provision of the necessary circuit and equipment facilities. Specifications are prepared in this department for such items as new buildings, the larger equipment installations, wire stringing work and important cable jobs. A great deal of engineering work is done in the application to the Long Lines of new apparatus and methods as standardized by the Departments of Development and Research and Operation and Engineering, and close contact is maintained with these departments. As is well known, the developments in new apparatus and methods applicable to long distance telephony and telegraphy have been rapid and of far-reaching importance. One branch of the department devotes its entire time to the design of circuit layouts. As was pointed out under the heading of "Telephone Repeaters", the design of long distance circuits requires consideration of each circuit as a whole, and it has been found desirable on account of the cost, length and complexity of most of the Long Lines circuits to have the plans for building them up prepared in one centralized organization. The matter of noise and inductive interference requires considerable attention.

All estimates for specific jobs are prepared in the offices of the division plant engineers and these organizations also do much detailed engineering work involved in the carrying out of construction projects and the preparation of specifications for the smaller equipment installations. Particular attention is also given to problems involved in maintenance methods.

Facilities of the associated companies such as subscribers' lines, switching trunks, and toll lines are used in connection with the plant of the Long Lines Department in the establishment of complete long distance telephone connections. Such facilities are, in general, those that can be most economically provided by the associated companies or have necessarily been provided by them in the operation of their business. In addition, many routes and desirable office locations of both companies are common. For these reasons the engineering branches of the Long Lines Department are constantly in touch with the organizations of the associated companies, in order that the economic advantages of joint construction may be considered and such facilities planned as will permit the business of each company to be handled in the most economical manner, considering the interests of the Bell System as a whole. Conferences are generally held each year in connection with the preparation of the construction program and at such other times as may be necessary in the preparation of fundamental plans or plans for specific projects. Representatives of the companies and departments interested are present and all available facts and data are carefully considered.

When the rapid growth and country-wide scope of the plant and activities of the Long Lines Department are considered, it is easy to appreciate that many variations in conditions and requirements are encountered, but in a sense these add interest to engineering problems already fascinating. The desirability of uniformly following methods and practices which experience has proven to be sound is always kept in mind in determining upon plans

for extensions of lines and equipment, and variations from these methods and practices are considered only when clearly justified by all of the facts.

To adequately meet the requirements of the public for long distance service, engineering plans for the Long Lines must be made on a broad and permanent basis, for experience has indicated that what is a line with but one or two circuits through a territory today, soon becomes a route carrying many circuits, and forming an important link in the national network of toll lines.

J. J. PILLIOD.

The Budget Plan of the Bell System

THE pages of history tell us of many ways by which mankind has sought to foresee and appraise the future. Soothsayers and astrologers, sibyls and oracles, all were held in high esteem in the life of their times. The bases for prophesies were many and varied; the position of the stars, the bones of lambs, nature's marking on stones, and many other things quite as irrelevant were all used. Great significance was attached to the interpretation of dreams, and we have a familiar example in the story of Joesph, who, from Pharaoh's dream of seven lean kine devouring seven fat kine, was able to anticipate the seven years of famine and, from the abundance of seven fat years, laid by stores for the lean years which followed.

With the advance of knowledge and lessons from experience, men have discarded these methods of appraising the future. They have learned that guesses, auguries, or "hunches" are unreliable guides and that the best assurance toward a prosperous future lies in careful planning for it—by studying what has happened in the past and, in the light of experience, surveying the problems and possibilities of the future so far as they may reasonably be foreseen. The wisdom of this course is universally recognized; by following it Governments hope to realize a partial solution of their present-day fiscal problems; modern business enterprises find in it a more scientific and safe way of directing their affairs, and even the twentieth century housewife finds it an excellent way to insure an abundance of "pin money" and to promote domestic happiness. Manifestly, other things being equal, the greater success and satisfaction will be realized by those who intelligently follow this program of planning carefully their future course.

Modern business in particular, when conducted on a large scale, has, by experience, come to realize the value of recording, classifying and analyzing its problems,

performance and potentialities in order to learn, if possible, what it may expect for the years which are to come. To this end carefully adapted methods of accounting and statistics have been developed to record the past and point to the future. By analysis of these the executive finds an indispensable aid in forming his judgments and directing intelligently his undertakings.

The Bell System with its immense problem—continually increasing in complexity—of performing a national telephone service for more than one hundred and ten million people, has not failed to appreciate the importance of utilizing this valuable and logical aid in conducting its affairs. For many years it has prepared a Budget Plan, or what is more familiarly known as the “Provisional Estimate.” From simple beginnings, this Budget Plan has been developed along with the growth of the business, until it has become one of the indispensable adjuncts to successful administration and operation of the national system. In fact, without it, the administration of an organization so large and complex as the Bell System would be exceedingly difficult, if not impossible.

THE NEED FOR A BUDGET PLAN

The Budget Plan or “Provisional Estimate” in the Bell System is a complete statistical summary of construction, operating and financial facts, both as they are presented by a pertinent period of past performance and as they may be forecast for a reasonable future period. It begins with an analysis of past experience and, in the light of that, searches the future and makes orderly preparation to move upon it. Those who administer the business have available a comprehensive picture of the growing and changing character of the business for the purpose of reaching well balanced judgments as to the lines of development necessary to meet the public needs and as to the best administrative policies and practices to be followed.

In the past, this Budget has been confined principally to a survey of the situation for one year in advance, set up in comparison with the realized performance of the present and past. However, the continually increasing demand for telephone service; the greater dependence upon the telephone as a means of simplifying and expediting the conduct of business and social life; the more highly technical character of the facilities required; and the increasing complexity of the entire undertaking, all require from those who furnish this service an ever increasing foresight. The most careful planning for future years is now essential. It demands, moreover, (to meet successfully this evolution in business and social life) the wise provision of great quantities of additional and improved facilities, many of which require several years for engineering, manufacture and installation; the preparation of the most economical programs for obtaining and expending the large amounts of money required; and the solution of numerous and complex construction, operating and management problems.

A few facts may be cited to illustrate this expansion in the Bell Telephone System and the size of its problem. At the end of 1900, there were 37,000 employees, 800,000 company owned stations, a plant investment of \$180,000,000, and net plant additions for that year of \$35,000,000. At the close of 1921, there were 224,000 employees, nearly 9,000,000 company owned stations, a plant investment of \$1,550,000,000 and net plant additions for the year of \$180,000,000. (It is interesting to note that the net additions to plant in the Bell System for 1921 alone were as large as the entire telephone plant investment in 1900, accumulated during the 25 years after the telephone was invented.)

The future does not promise any slackening in the demand for additional service. New facilities must be added, equipment must be replaced, in brief the telephone structure must keep pace with our national development. Obviously, the many complicated problems presented by this widespread telephone structure, with

its rapid growth, require most careful study of what has happened and most comprehensive analysis of the needs and possibilities of the future. To meet this situation, and to obtain a better appreciation of the effects of general industrial and economic conditions upon the demand for telephone service and the requirements involved in these demands, it is necessary to look further into the future than we have in the past so that the task of rendering telephone service may be better visualized, and its problems anticipated and provided for intelligently in advance. To this end, the Bell System, during the past year, has substituted for its one-year plan a five-year Budget, by means of which it aims to obtain as comprehensive a picture as possible of the task ahead of it for at least that period. This five-year program, stepped up annually by adding one year and by correcting for previously unforeseen situations, provides a continuous and dynamic forecast of the problem before the Bell System.

THE CHARACTER OF THE BUDGET PLAN

This fundamental and continuous five-year Budget Plan aims to provide data which is truly comprehensive and well balanced from all points of view. The facts brought together are intended to show why and how certain things should be done, and what may be expected, particularly in development, capital costs, revenues, expenses and net return, as the result of the action proposed. Accordingly, past performance is tabulated and the reasonable assumptions for the future are set up in comparison. In the preparation of this picture, practically every department of the company is in some way or another concerned.

As a preliminary step the Executives must make available a tentative program of general policies in respect of the business and its future development, so that the several departments may have a basis upon which to proceed in bringing together the material for

that part of the picture for which they are immediately responsible.

The Statistician must give his picture of economic and financial conditions, as these may be anticipated, with their probable effect on development; he must analyze business and labor conditions and the probable trend of interest rates and the money market. The telephone business, it is true, continues to increase with remarkable evenness year by year, in spite of wars, business depressions, and other disturbing factors and, in general, is by no means as much affected by external influences as manufacturing, mercantile, and other business; nevertheless, economic influences cannot be disregarded and no estimate of the future of the telephone problem will be fully significant which does not incorporate the result of careful study of economic factors such as the increase in national wealth, the tides of immigration, the increase or decrease in population, distribution of income, and housing conditions.

The Commercial forces must estimate as carefully as possible the increase in population in the territory to be served, the growth of cities and other communities, the extent to which these changes will influence the increase in stations, and the prospective use of telephone facilities by patrons. Possible new forms of service must be studied and their effect on the business ascertained; estimates must be made of the probable revenues which may be expected from each class of service which is or may be offered.

The Traffic forces must survey the requirements for handling the service demanded, in the way of both equipment and personnel. Related labor supply and costs must be studied. Various methods of handling traffic must be considered to find the most efficient and economical practices and types of equipment. All of these must be resolved into expected capital expenditures and operating costs for the period.

The Engineering and Plant forces must consider the traffic and service requirements as forecast for the future,

and determine the amount of additional facilities required, the types of plant best adapted to meet efficiently and economically the demands for service as they are foreseen. They must also give consideration to spare facilities, and their fundamental plans must be such as to lay the foundation for meeting still greater service demands in the future in an orderly step by step progression along sound and carefully worked out economic lines. Replacement and rebuilding of plant and equipment must be considered and proper provision made for the maintenance of the property. All of these and many other factors must be resolved into plant, labor and material requirements, capital expenditures and operating expenses.

The Accounting forces must provide from their records data as to past performance of every phase of the business. They must also estimate and summarize future requirements as to taxes, fixed charges, dividends, and general and miscellaneous expenditures. Items of revenue must be estimated and tabulated.

In fact, every function of the business must outline its program of activities for the period, justify their value to the business and appraise the cost and results thereof, and all of these judgments and estimates brought together, co-ordinated and summarized, comprise, for the Executives, a Provisional Estimate of the task and its probable results immediately ahead of the Bell Telephone System. The picture is by no means complete, for many unforeseen situations and contingencies will arise to modify the work as planned and the results expected. Estimates also are sometimes influenced by hope of accomplishment rather than by an analysis of the cold facts, but nevertheless a valuable fund of data has been made available.

THE USE MADE OF THE BUDGET PLAN

This fund of information regarding the future of the business enables the administrative and executive offi-

cials to consider the soundness and wisdom of their policies and programs for the future. They must review the possibilities in respect of general business conditions, price changes, labor conditions and wages, the demands for service, the requirements for plant additions, improvements and replacements, the requirements for maintenance, operating and general expenses, depreciation, and taxes. They must give due consideration to unforeseen contingencies and make due allowance for estimates of the future based on scanty data. They must eliminate the non-essential in the plans as proposed. The adequacy of the present rate structures must be studied, the revenues expected from new developments must be carefully scrutinized, and a conservative appraisal made of the possibilities of increased revenues. The prospects of obtaining the new capital required must be considered and the probable cost thereof ascertained.

In brief, those who administer the business must obtain a full knowledge of what is involved in their responsibility for furnishing adequate and efficient telephone service for the future, whether their policies and the programs as proposed by the several functions can be executed, or whether they should be revised, modified or discarded. However, beyond this they must satisfy themselves that the program which is finally adopted will yield a proper and reasonable amount of net earnings on the investment required, otherwise that program, no matter how splendidly planned, must fail, for investors will not long supply the additional capital required unless they are assured of the protection of their investment and an adequate return thereon.

In meeting these two major responsibilities, namely, adequate and efficient telephone service to the public and an adequate return to those who invest their labor and money in the business, the data provided by the Budget Plan furnishes the executives with a continuing basis for action. With its aid they can lay plans for the future and arrange for the conduct of operations in an orderly and economical manner from every viewpoint.

A few of the advantages made possible may be mentioned.

From the viewpoint of future material requirements, when one stops to consider that the purchases of equipment and construction and other materials required by the Bell System now exceed \$150,000,000 annually and that these for the most part are highly fabricated and specially manufactured for its purposes, it becomes evident that construction and service programs must be anticipated and requirements furnished to the suppliers at least several years in advance, in order that equipment and supplies may be manufactured and delivered under normal schedules. Time should also be available for reasonable foresight as to price changes, to enable a more liberal purchasing of materials during periods when prices are at relatively favorable levels. The supply of raw materials now used may become limited and it may be necessary to find new sources or substitutes if delay and inconvenience are to be avoided. Deliveries of material can be scheduled and made available by the supplier in an orderly manner so that no delay will result when work on a project is started. At the same time, the manufacture and delivery of equipment can proceed in such a way as to limit to the minimum the preliminary non-earning period of capital tied up therein.

From the viewpoint of construction and maintenance work for the future, large and important developments and projects can be studied and possible alternative plans considered to find the best and most economical way to meet the desired result. Switchboards and installations must be engineered, and construction activities co-ordinated. Replacement and maintenance programs may be prepared. The necessary workmen can be trained in advance so as to be skilled and experienced in their work. The general demand for and supply of available labor can be analyzed and a continuous program of work arranged so that skilled labor may be continually employed. In brief plans may be made to conduct the necessary operations year after year on an even keel

without undesirable changes in working forces and labor turnover.

From the viewpoint of operation, there is afforded an opportunity to study increased service demands, and if these require that methods of handling traffic be revised, or that new and better facilities be provided or new methods designed to meet the requirements, this can be done. The necessary operators may be trained and the source of supply analyzed to ascertain whether the needs of the System can be met or whether other methods of handling the traffic must be employed. Anticipated operating expenses of every type may be scrutinized and plans laid to ensure the latest and most economical methods.

From the viewpoint of revenues which are required to make possible the success of any program adopted, the Budget Plan provides an opportunity to plan carefully in advance for rate schedules which will be adequate and consistent with the quality of service rendered, yet reasonable in cost and adapted to develop traffic. New sources of revenue may be arranged by more effective and intensive uses of the service. Rate situations may be systematically studied and equitably adjusted so that expensive rate litigation may become necessary only as a last resort.

From the viewpoint of supervision, the data so made available affords an excellent means of checking actual performance. If the estimates take full account of all of the conditions under which the proposed work must be done, and its actual performance presents higher costs or other unfavorable conditions, an opportunity is afforded to check whether the work was done efficiently and economically, or whether it is properly organized and supervised; in brief, whether the desired result is being obtained at the lowest possible cost.

Finally, one of the major functions performed by the Budget Plan is to lay a sound foundation for financing. After the entire program for the immediate future has been summarized, checked and revised to a sound basis,

consistent with the expected demands for service and conservative as to cost, the problem presented is that of financing the undertaking. All proposed activities must be resolved finally to capital costs and net earnings. If net earnings are not adequate to yield a proper return, one of two courses of action must obviously be taken—either more revenues must be made available or the program must be modified. The large army of investors in Bell System stocks and bonds—numbering upwards a half million—must realize as much on their funds in this business as from other forms of investment, otherwise their funds will be withheld. The Budget makes it possible to so plan the future of the business as to retain these investors and to interest others, while rendering service at a reasonable price.

The capital cost of any program approved must be obtained by new investments from those who are already investors and by developing new sources of capital, and to this end, the Budget permits a continuous forward-looking financial program in respect of the large amounts of new capital required. During the past few years, these capital requirements have averaged upwards of \$100,000,000 annually. To make available at the minimum cost to the Bell System, these immense amounts of new capital and to have funds on hand as needed is indeed a task of no small proportions. Consideration must be given to the best form of security to be issued—whether stocks, bonds or notes—and the most favorable time for issuing these must be determined. The conditions of the investment money market and the trend of and possible changes in interest rates must be critically considered. New sources of capital must be tapped and confidence must be established and maintained in the securities issued. The foundation must also be laid for future issues, since the business is a continuing one and the demand for telephone service shows no signs of slackening. But the task of financing can be carried to successful completion only if net earnings are and continue to be such as attract and hold capital in the business, and in this

connection, the Budget Plan appraises anticipated earnings and gives a basis for making every possible effort by sound planning and economies to make them adequate now and for the future.

The American Telephone and Telegraph Company and its Associated Companies comprising the Bell System have as their responsibility to society the task of furnishing a national telephone service. In performing this task the development of a well organized and intelligent force of men and women has been necessary and an investment aggregating over two billion dollars is now involved. The size of this undertaking has not come about by the personal desire of any one individual or group of individuals in the Bell System that the organization and structure which provides this essential service should be the largest of its kind, or that an enormous volume of service should be rendered as a business venture; rather, this structure has been made necessary by and created out of the demands of society that it be supplied with this indispensable instrument in the conduct of its business and social life. For the same reason, the business will assume even greater proportions, more complex service and operating problems will be encountered and much additional capital must be obtained.

This responsibility for the future can and will be met, but to that end a careful study of past performance is required, and careful and logical planning for the future must be in evidence, to assure that development and growth will proceed in an orderly, economical and stable manner. On this account, a continuous scientific Budget Plan, which lives and grows with the business and is always adapted to the needs of the time is indispensable.

C. A. HEISS.

Electric Waves—The Modern Mercury

ALL intelligence is brought to us by waves of one form or another. Hearing and sight are the familiar illustrations, one depending upon air waves and the other upon the so-called ether waves. The telephone and telegraph, whether wire or radio, are equally good examples. Like the sense of sight they depend upon ether waves. In the radio telephone and telegraph the waves bearing messages spread out through space in all directions; in the wire telephone and telegraph they travel very close to the line wires which serve as guides between the sending and receiving points.

The familiar expression is that the electric "current" transmits telephone and telegraph messages. This is only a partial picture. An electric current in a wire implies the presence of electric waves in the region surrounding the wire, and physics teaches that the energy of the "current" is to be found in these waves. This conception of the transmission of energy is deducible

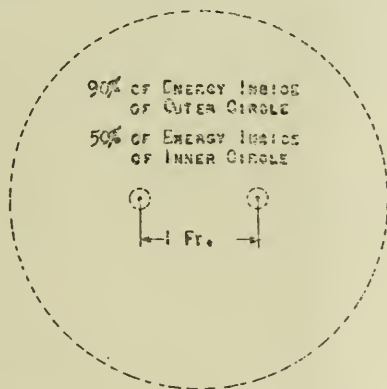


FIG. 1. Energy Distribution with No. 8 B.W.G. Open Line Circuit Carrying A. C. Currents

from Maxwell's fundamental postulates and will be found elaborated in the writings of Poynting, in 1884, J. J. Thompson, in 1893, and Heaviside, in his *Encyclopædia Britannica* article in 1902. When a current of electricity flows in a wire it represents the drawing of energy from

the surrounding ether waves, and if the current could be prevented the waves would travel with less tendency to die away.

The extent to which wires act as guides for the energy of the electric waves may be illustrated by a long open-wire telephone circuit. From Fig. 1, showing a section of such a circuit, it is seen that the ether immediately around the wires acts like a sort of duct through which the energy passes.

Electric waves used in telephony and telegraphy, both wire and wireless, belong to the same category of ether waves as the light waves of the visible spectrum and the infra-red, ultra-violet, and X-ray spectra. They are, however, of much higher frequency. The relative frequencies of the principal portions of the ether wave spectrum thus far studied and classified are given in Table I. At one end lie the extremely short X-rays whose wave length are of the order of a billionth of an inch, a distance that is comparable with the distance between the atoms of most crystals. At the other extreme come the very long waves used in electrical communication whose lengths range all the way from many feet to many miles.

TABLE I

	Frequency in Cycles per Second
Wire transmission systems.....	0 to 30,000
Radio.....	15,000 to 10^7
Hertzian Waves.....	10^7 to 10^{10}
Infra-Red.....	10^{12} to 4×10^{14}
Visible.....	4×10^{14} to 8×10^{14}
Ultra Violet.....	8×10^{14} to 3×10^{15}
X-Rays.....	about 3.5×10^{17} to 5×10^{18}

The view that all ether waves are fundamentally alike—whether X-rays or the long waves used in communication—originated in the theoretical work of Maxwell and the experimental work of Hertz. Notwithstanding the fact that every wire carrying an electric current is surrounded by long ether waves, their existence became known only when Hertz succeeded, so to speak,

in shaking them loose from their wire paths making them free to radiate in all directions. Because they originate about an electric circuit they are frequently referred to as *electric waves*, but the very much shorter waves of light are as truly electrical in origin.

So far as is known, all ether waves travel with a common speed, namely, 186,000 miles a second. This speed has been accurately measured for the waves of the visible spectrum and also for the long Hertzian waves. The speed of X-rays has not as yet been directly determined but there is no reason to believe that they form an exception to the general rule.

The question is frequently asked and seldom answered correctly as to the speed at which telephone and telegraph messages travel over long circuits such as that between New York and San Francisco or a submarine cable under the Atlantic Ocean. As a matter of fact the answer is very simple. As already pointed out the electric waves travel along the wire or cable with the speed of light. On this basis, the waves constituting a telegraph message would require less than $1/50$ of a second to travel from New Foundland to Ireland, a distance of about 2800 miles. This does not mean, however, that the message sent from New Foundland will be *reproduced* at the receiving station on the Irish coast within $1/50$ of a second. The reproduction of the message requires movement on the part of the receiving instrument and this in turn depends upon the building up of an appreciable electric current in the receiving end of the cable. It is the building up of the current and the production of motion which requires time. In the case of the Atlantic cable some *three* or *four* seconds is required.

To put this another way, a telegraph or telephone message represents a case in which "coming events cast their shadows before." Along the surface of the wire and outside of it, the electric impulses or waves travel with the speed of light. After the initial impulse has passed, current in the same direction as this impulse proceeds to build up. The rate at which the growth

occurs depends upon the electrical characteristics of the circuit, it being much slower in a submarine cable than in an open wire telephone or telegraph line. With the lapse of more or less time after the initial impulse, the current in the wire becomes large enough to operate the receiving instrument whether this be a telegraph sounder, a telephone receiver or a syphon recorder.

One of the most characteristic phenomena connected with wave motion is that of "resonance". Doubtless everyone has at some time made the acquaintance of a piano which attempts to talk back to him. This effect can be secured from any piano by lifting the dampers from the strings by means of the sustaining pedal. When free to vibrate, each string tends to be set into sympathetic vibration by those sound waves of the voice which correspond to its particular frequency. By gently pushing down a single key on the piano so as not to cause the string to vibrate and then singing that note, a very good illustration of sympathetic vibration or resonance is obtained. By holding down several keys and singing only one of them it will be found that that one alone responds by resonance. This gives a very simple illustration of the principle of "tuning" as practiced in radio telephony and telegraphy. Carrying out the analogy, each string may be looked upon as a radio receiving station, only that single one being set into motion whose rate of vibration is the same as that of the sending station.

What is more natural than to attempt the transmission of several telegraph messages over a single wire at the same time by employing this principle of resonance? As much as fifty years ago, we find that two notable attempts were made to develop an "harmonic" telegraph. About 1872 Elisha Gray and Alexander Graham Bell independently set out to solve the problem, making use of mechanical resonance as displayed by vibrating strings and reeds.

Gray succeeded in bringing his invention to a remarkably high state of perfection but it did not prove capable of the important practical applications for which he had

hoped. Bell, on the other hand, encountered difficulties and digressed from his original plan due to certain curious observations which he accidentally made. He failed to complete his device but by digressing he came upon another very useful invention, the telephone. He had for some time had visions of a device for transmitting speech electrically, and when he detected what he thought was a clue to it in his accidental observations, he straightway bestowed all of his energies upon it.

The fundamental properties of all wave motion, whether found on the surface of water, or in the air, or sounding bodies, or in the ether of space, are practically identical. This does not mean that sound waves in air and electric waves in the ether are identical. It means that the mathematical equations which the physicist uses in his study of these two kinds of waves are similar.

A partial justification of this statement is found in the fact that the phenomenon of resonance as displayed by sounding bodies is paralleled accurately by resonance in electric circuits. The "tuning" of a wireless receiving set consists simply in changing its natural rate of electrical vibration so as to be equal to the rate of some station which is sending out messages. When so tuned, it is relatively sensitive to the wave length sent out by this station and relatively insensitive to stations transmitting on other wave lengths.

With the discovery of electrical resonance and its close parallelism to mechanical resonance, there came renewed efforts to develop an harmonic telegraph. Naturally the new attempts involved the principle of electrical tuning as a substitute for the mechanical tuning used by Gray and Bell. About the year 1893, Pupin and John Stone Stone, an engineer of the American Bell Telephone Company, began working upon a system of harmonic telegraphy involving electrical tuning. Its fundamental idea was that the dots and dashes of the telegraph code should be carried by relatively high frequency currents, the simultaneous messages being each carried by a different frequency. Except for the fact that these high

frequency currents were to be guided by wires and not radiated in all directions into space, the underlying principles were the same as those at present employed in wireless telegraphy.

About the same time Stone, in this country, and Messrs. Hutin and LeBlanc, in France, were attacking the problem of what might be called an harmonic telephone. Just as in the telegraph the effort was to carry dots and dashes by alternating currents of frequencies ranging from about 200 to 500 cycles per second, the seekers after the harmonic telephone proposed to carry the rapid fluctuations of the voice by alternating currents of higher frequencies between 10,000 and 20,000 cycles per second. By the use of several such high frequency currents they hoped to transmit several telephone messages at once over a single pair of wires. Like Pupin, they made use of tuned circuits and electrical resonance. These pioneers in the field of harmonic telephony—or “carrier current” telephony, as it is known today—were able to make their inventions work under favorable conditions but they proved too delicate, too unreliable, to be practicable for public use. Although means were provided for the simultaneous transmission of several messages over a single circuit, the complications involved over-balanced any advantages that the multiplex feature might have.

An explanation of the failure which met the efforts of these pioneer investigators is found in the undeveloped state of the art of transmitting currents over wires which prevailed at that time. In the light of our present-day knowledge we see that the solution of harmonic telephony demanded certain devices which were not then to be found even in the imaginations of the foremost investigators. Nor were these essential devices immediately forthcoming; for during the years 1906 to 1911 a number of workers, among whom may be mentioned Vreeland, Squier and Alexanderson in this country and Ruhmer in Europe, suggested multiplex carrier telephone and télégraph systems which employed the same fundamental

principles previously worked upon by Pupin, Stone and others and with no better success.

The successful application of carrier currents has been a development of the past four or five years and looking backward, we can now see the factors that have turned failure into success. The most important of these are three in number:

1. Development of the familiar vacuum tube to such a state that it is a reliable and stable instrument for amplification, detection and modulation of electric currents.
2. Development of a device known as an electric wave filter which represents a vast improvement over the tuned circuit as a means of separating electric currents of different frequencies.
3. Development of the technique of transmitting telephone and other currents over wires, with

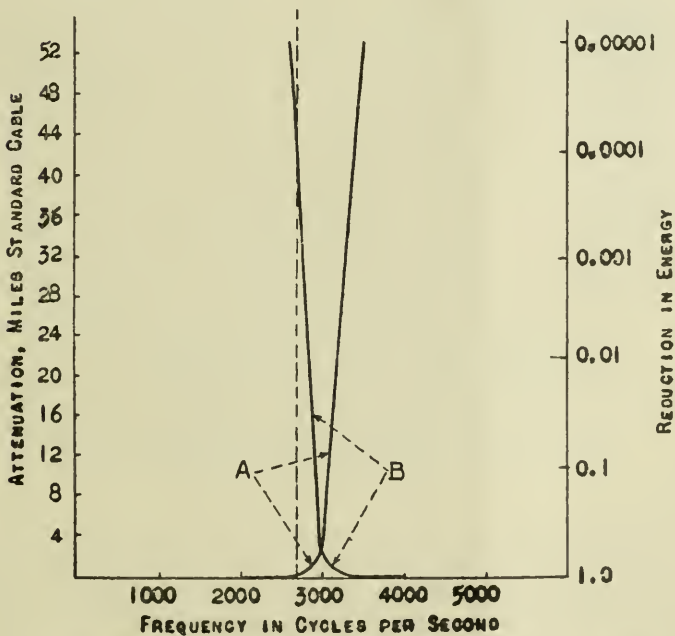


FIG. 2. Transmission characteristics of "Low Pass" filter (curve A) and "High Pass" filter (curve B).

particular reference to telephone repeater operation and the methods of overcoming interference or "cross-talk" between adjacent circuits.

These developments have emanated from the research laboratories of the Bell Telephone System, and indeed could scarcely have been possible except through the close cooperation and the careful dovetailing together of almost countless individual pieces of research which a large laboratory organization makes possible.

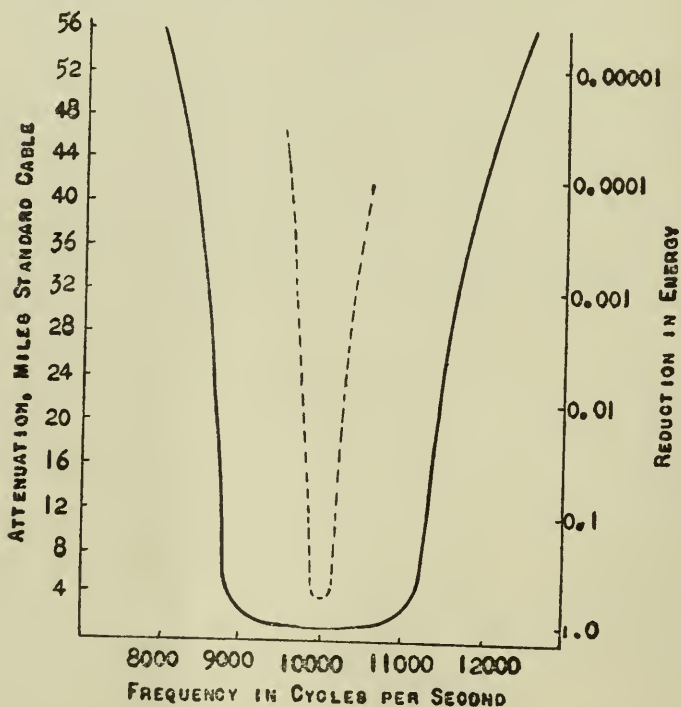


FIG. 3. Characteristic of a "Band Pass" filter (solid curve) designed to admit frequencies between 9000 and 11000 compared with that of a resonant circuit (dotted curve).

The electric wave filter is one of the most remarkable developments of recent years in the field of electric circuits. The filter makes it as easy to separate alternating currents of different frequencies as screens with different sizes of mesh make possible the separation of stones and

gravel of different sizes. It is the invention of Dr. G. A. Campbell of the American Telephone and Telegraph Company and were it not for the unfortunate fact that any comprehensive understanding of its action involves quite a bit of higher mathematics, it doubtless would be much more widely known today than it is.

The filter does not respond to electric currents in the same manner as the tuned circuit. It acts as a gate which can be placed in any circuit and which will admit

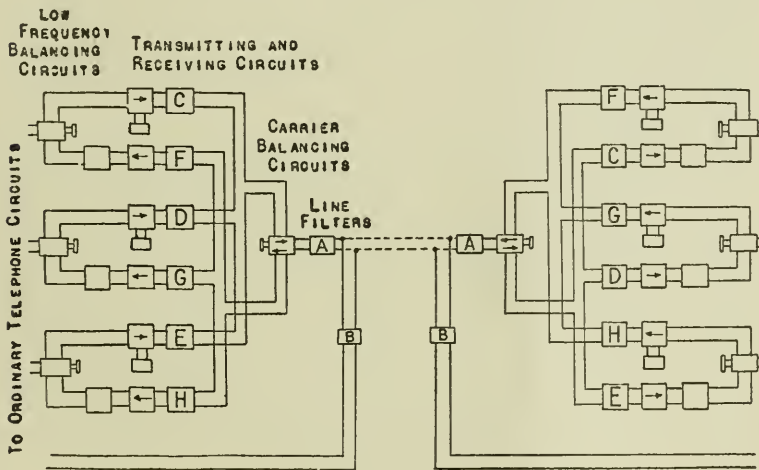


FIG. 4

- A, Band-pass filters admitting all carrier frequencies but excluding the band of voice frequencies.
- B, Band-pass filters admitting the voice frequencies but excluding all carrier frequencies
- C, Band-pass filters covering the range from 10,000 to 12,500 cycles.
- D, Band-pass filters covering the range from 13,500 to 16,000 cycles.
- E, Band-pass filters covering the range from 17,000 to 19,500 cycles.
- F, Band-pass filters covering the range from 20,000 to 22,500 cycles.
- G, Band-pass filters covering the range from 23,500 to 26,000 cycles.
- H, Band-pass filters covering the range from 27,000 to 29,500 cycles.

only currents of predetermined frequencies. For example, a filter can be designed which will admit currents from zero frequency to any higher frequency such as 200 cycles. Or the filter may be designed to admit all currents between two definite frequencies as, for instance,

200 cycles per second and 500 cycles per second. Or again, it may be designed to admit all currents above a certain frequency. These filters are known respectively as "low-pass", "high-pass" and "band-pass" filters and the general characteristic of each is shown in Figs. 2 and 3.

The selectivity of the filter as shown by the solid line in Fig. 3 is remarkably uniform over any range of frequencies for which it may be designed—in Fig. 3 this range is from 9,000 cycles to 11,000 cycles. For comparison, the selectivity of the resonant circuit is shown by the dotted curve and, as will be seen, is great in the immediate neighborhood of 10,000 cycles but diminishes rapidly on either side.

The manner in which filters are used in a modern carrier telephone circuit is shown diagrammatically in Fig. 4. Each telephone channel must supply means of transmitting speech in both directions. This is generally accomplished by using a different carrier frequency to transmit in each direction. In our diagram the lowest carrier frequency has been taken as 10,000 cycles per second. When this is modulated with speech it becomes a band of frequencies ranging from 10,000 cycles to about 12,500 cycles because the band of speech frequencies is itself about 2,500 cycles wide. The next carrier frequency must, therefore, be somewhat greater than 12,500. In our illustration it has been chosen as 13,500. This in turn when modulated with speech becomes a band of frequencies ranging from 13,500 to 16,000. The next carrier channel runs from 17,000 to 19,500. As shown in the diagram these three channels carry speech from west to east. To carry it from east to west three other channels running from about 20,000 to 30,000 cycles are employed. In this way the likelihood of the westbound channel A cross-talking into eastbound channels B or C is reduced to a minimum. This is a very important point for, as already indicated, the elimination of cross-talk between adjacent carrier circuits has been one of the most difficult problems for the telephone engineers to overcome in arriving at a successful carrier system.

Of equal importance with the filter has been the development of a successful telephone repeater. This, as is generally known, employs the three-electrode vacuum tube as one of its integral parts. The rise of the vacuum tube to a position of importance in the electrical art has been extremely rapid. It first assumed commercial importance by its use in the telephone repeaters of the transcontinental telephone line when that was opened in 1915. The studies which were made by the telephone engineers to adapt the vacuum tube to long distance telephony in the transcontinental line demonstrated that this remarkable device could also be made the keystone of a practicable radio telephone, and the development of power vacuum tubes very much larger than any theretofore made was immediately undertaken. With these tubes speech was successfully transmitted in the fall of 1915, from the city of Washington across the Atlantic to Paris and also westward, a distance of 5,000 miles, to Honolulu. It was the success of this first large radio telephone demonstration that proved that radio telephony could be made sufficiently reliable for military purposes. Many new investigations were therefore begun by the telephone engineers in cooperation with the U. S. Signal Corps, with a view to perfecting small radio telephone sets for air-craft, submarine patrols and many other war-time uses.

Without the telephone repeater there would be no practicable carrier telephone system. Some experimenters in the field of carrier currents have had the curious misconception that the mode of transmission of the high frequency electric waves employed in carrier operation is different from that of the ordinary telephone and telegraph frequencies and that the carrier frequencies have some unexplained property whereby, although guided by the line wires, large energy losses in the wires are avoided. There is, however, no theoretical or experimental justification for this idea. As a matter of fact, a high frequency carrier current tends to die away more rapidly in traveling over a long line than does the ordinary tele-

phone current. The higher the frequency the more rapidly does it die away.

To indicate the importance of telephone repeaters in a carrier system it may be stated that if the Harrisburg-Chicago carrier telephone line, 750 miles long, were operated without repeaters it would be necessary to apply at the sending end a power of 60 kilowatts; by the use of intermediate repeaters the power at no point exceeds $1/600000$ th of this figure, or $1/10$ watt. Since the difference between the two cases is represented by a factor of 600,000, it need scarcely be added that without telephone repeaters the carrier system would be utterly impracticable except perhaps on very short circuits. On short circuits, however, it is cheaper to provide additional line wires than to resort to the complications which are necessarily involved in the carrier system.

One of the most interesting and noteworthy features of the development of harmonic or carrier current telegraphy and telephony has already been hinted at. Upwards of half a century ago two inventors—one of them the subsequent inventor of the telephone—strove to perfect a harmonic telegraph. They were both men of vision—of vision so keen and far-sighted that they attempted what would ultimately come to be of great service, but which was far in advance of the electrical art of their day. The art had not then dreamed of the essential stepping stones by which the desired end was to be reached—the vacuum tube and the filter. By the development of these and countless other and less conspicuous improvements in the transmission of communication currents over wires, the telephone engineers of today have reached the goal for which the inventor of the telephone strove and by which efforts he was led to the telephone itself.

R. W. KING.

Notes on Recent Occurrences

THE SHAWNEE CONFERENCE

DURING October a Bell Telephone System conference to discuss economy and efficiency in operation was held at the Buckwood Inn, Shawnee-on-Delaware, Pennsylvania.

Shawnee-on-Delaware is a little town about four miles from Delaware Water Gap. It lies in the floor of the valley where the Delaware River cuts through the Pocono hills.

The conference was attended by the officers responsible, in each of the Associated Bell Telephone Companies, for coordinating the work of the plant, traffic, commercial and engineering departments.

The spirit of the conference was expressed by Mr. H. B. Thayer, President of the American Telephone and Telegraph Company, in his opening remarks. In discussing the purposes of the conference Mr. Thayer said, "We invest about two hundred million dollars a year. In investing this money we have to think about two things—of giving service to the American public, and that the dollars must be spent in a way that will give the most service for the least money and will be of the greatest good to the most people. It is not an easy proposition, in spending two hundred million dollars, to say just where it should be spent to accomplish the greatest good to the greatest number.

"We are spending largely the money of small investors, more than half of them women—to a greater extent, we believe, than in any other enterprise. We are really trustees for these investors. We must spend this money in a way to insure the surest return. This is a big responsibility. Having spent the money, the property created by it must be operated, and it must be operated to the satisfaction of the public. It must be operated at an expense that the public will approve. There isn't any business in the United States where there is more intimate

criticism of the operation of the business than there is in the telephone business. There isn't any business where the public served feels itself as directly affected by bad service as it does in our business. The public expect a high degree of perfection. This is one of the things we must always think of.

"Besides this matter of giving service, we have in operating the business the very important duty of seeing that no one can justly make the statement that we are either spending money extravagantly on plant, or extravagantly on service. We cannot proceed like the motorman driving a street car, where it is simply a case of going ahead and keeping on the track. We must be constantly thinking, always thinking of the possibilities of next week, next month, next year. The job is not a routine job. We have a responsibility to try and see what it is, at this particular time, that the Bell Telephone System needs most, in addition to those things we all know about and are here to talk about, the necessity of increasing foresight, increasing economy, increasing efficiency."

Later in the conference Mr. Thayer stated: "At this meeting I am very much impressed with the fact that more and more we are operating this business on the basis of accurate knowledge and trained experience." This seems to sum up the work of the conference, which lasted eight days, and which was devoted to a detailed discussion of ways and means of accomplishing the objectives outlined in Mr. Thayer's opening remarks.

The conference was a valuable experience to all who were there. It permitted the operating officials of the System, the daily work of each of whom is conducted in a different part of the nation, to meet together in one room and to discuss common and individual problems. The fact that the conference was held in the country, away from the distractions of the big cities, permitted its work to proceed without interruption, and allowed the members of the conference to carry on their discussions among groups outside the regular sessions. Those who

Notes on Recent Occurrences

were at Shawnee expressed themselves as impressed with the value not only of the conference itself, but of the general discussions, outside the conference room, which the holding of the conference at Shawnee permitted.

Those who attended the conference were:

NEW ENGLAND TELEPHONE AND TELEGRAPH COMPANY—

W. R. Driver, Jr., *Vice President and General Manager*
G. H. Dresser, *General Superintendent of Plant*

SOUTHERN NEW ENGLAND TELEPHONE COMPANY—

H. C. Knight, *Vice President and General Manager*

NEW YORK TELEPHONE COMPANY—

J. A. Stewart, *First Vice President and General Manager*

BELL TELEPHONE COMPANY OF PENNSYLVANIA—

J. C. Lynch, *Vice President and General Manager*
J. L. Kilpatrick, *Assistant Vice President and Assistant General Manager*

CHESAPEAKE AND POTOMAC TELEPHONE COMPANY—

B. Stryker, *General Manager*

SOUTHERN BELL TELEPHONE AND TELEGRAPH COMPANY—

F. H. Reid, *Vice President*

OHIO BELL TELEPHONE COMPANY—

C. P. Cooper, *Vice President and General Manager*

CINCINNATI AND SUBURBAN BELL TELEPHONE COMPANY—

B. T. McBurney, *Vice President and Assistant General Manager*

INDIANA BELL TELEPHONE COMPANY—

F. A. Montrose, *Chief Engineer and General Plant Superintendent*

MICHIGAN STATE TELEPHONE COMPANY—

G. M. Welch, *Vice President and General Manager*

WISCONSIN TELEPHONE COMPANY—

W. R. McGovern, *President*

ILLINOIS BELL TELEPHONE COMPANY—

F. O. Hale, *Vice President and General Manager*

SOUTHWESTERN BELL TELEPHONE COMPANY—

A. B. Elias, *Vice President*

NORTHWESTERN BELL TELEPHONE COMPANY—

A. A. Lowman, *Vice President and General Manager*

MOUNTAIN STATES TELEPHONE AND TELEGRAPH COMPANY—

E. M. Burgess, *Vice President*
H. E. McAfee, *General Commercial Manager*

PACIFIC TELEPHONE AND TELEGRAPH COMPANY—

J. C. Nowell, *Vice President and General Manager*

LONG LINES DEPARTMENT—

F. A. Stevenson, *Director*

BELL TELEPHONE COMPANY OF CANADA—

C. F. Sise, *Vice President and General Manager*

WESTERN ELECTRIC COMPANY—

F. B. Jewett, *Vice President*

F. B. Gleason, *General Telephone Sales Manager*

AMERICAN TELEPHONE AND TELEGRAPH COMPANY—

B. Gherardi, *Vice President and Chief Engineer*

E. K. Hall, *Vice President*

C. A. Heiss, *Comptroller*

K. W. Waterson, *Assistant Chief Engineer*

R. H. Burcher, *Assistant Vice President*

C. I. Barnard, *Commercial Engineer*

H. P. Charlesworth, *Plant Engineer*

W. A. Griffin, *Assistant to Vice President Hall*

MACHINE SWITCHING IN NEW YORK CITY

THE first machine switching telephone central office in New York City was placed in service on October 14, at midnight, when 1700 lines of the Pennsylvania exchange, which numbers several of the larger metropolitan hotels and department stores among its 10,000 subscribers, were “cut over” from the manual switchboard to the new mechanical equipment.

An intensive campaign of personal instruction to subscribers had been carried on by the New York Telephone Company, with the result that no difficulty was experienced in the use of the dial and the new apparatus is functioning with satisfaction to both the telephone users and the company.

On November 18, approximately 1200 additional lines of the Pennsylvania exchange were transferred to the machine switching equipment, and others are to be added gradually until the entire exchange has been put on a mechanical basis.

The second office to be transferred to the machine switching equipment was Academy, serving one of the

uptown residential districts. On December 2 about 4,000 lines served by the manual type of switchboard of this exchange were "cut over", and others are to follow shortly. The next exchange scheduled for transfer to the machine switching equipment is Walker.

The transfer of the Pennsylvania exchange is the first of a series contemplated by the New York Telephone Company. Difficult engineering problems are involved and the manufacture of the intricate apparatus used in connection with the machine switching equipment requires the most painstaking accuracy in every detail.

A. T. & T. CO. HEADQUARTERS

CONSTRUCTION of an addition to the Telephone and Telegraph Building, New York, national headquarters of the Bell System, which has been under way for some time, has been completed and the ground floor was thrown open to the public on November 1. The frontage on Broadway now extends from Dey Street to Fulton Street, the depth being about 275 feet on the former and about 167 feet on the latter. The Telephone and Telegraph Building now occupies a total ground space of 36,000 square feet. It has twenty-six floors.

The Greek style of architecture employed in the old building has been followed in the new structure, Doric columns being used in the lobby and for the first floor exterior, while the exterior columns on the other floors are Ionic. Simplicity and dignity, combined with an impression of enduring strength, are outstanding characteristics.

In no case has utility been sacrificed to artistic effect and the result is a building which is as near perfection from the standpoint of utility as it is from that of beauty. Thirty elevators carry the occupants of the offices to and from their work, while the enlarged lobby prevents congestion, even during the busiest hours of the day.

The heating, lighting and ventilating systems are ideal. The mechanical department, which houses the engines and dynamos used in connection with these systems, is located in sub-basements which extend three floors below the ground level.

Besides the headquarters organization of the American Telephone and Telegraph Company and certain departments of the Western Electric Company, the manufacturing branch of the Bell System, the building is occupied by the executive offices of the Western Union Telegraph Company. Its present occupants number about 4,400 but provision has been made for a maximum capacity of 6,000. This will care for the expansion of the telephone organization for some time to come.

VAIL MEDAL AWARDS

ON December 1, the National Committee of Award announced the names of ten men and women to whom they had awarded the gold and silver medals conferred annually upon members of the Bell Telephone organization in memory of the late Theodore N. Vail, and in recognition of a few of the most conspicuous examples of "noteworthy public service."

In addition to the gold and silver medals, 144 bronze medals were awarded by regional committees of award, and from these ten were selected as winners of the gold and silver medals. The gold medal carries with it a cash award of \$500, and each of the silver medals a cash award of \$250.

The gold medal was awarded to Byron Ernest Thady, night switchboard man of The Mountain States Telephone and Telegraph Company, of Pueblo, Col., for his services during the flood which occurred in that city on June 3, 1921.

The silver medals were awarded to:—

Lillian Elizabeth Barry, supervisor, Southwestern Bell Telephone Company, St. Joseph, Mo.

Notes on Recent Occurrences

Anna Regina Murphy, chief operator, The Bell Telephone Company of Pennsylvania, Carbondale, Pa.

Otis Payne, lineman, Indiana Bell Telephone Company, Washington, Indiana.

Mrs. Josephine D. Pryor, chief operator, The Mountain States Telephone and Telegraph Company, Pueblo, Col.

Robert W. Taylor, foreman, Cumberland Telephone and Telegraph Company, Winona, Miss.

Verda Ray Townley, manager, Southwestern Bell Telephone Company, Freeport, Tex.

Alphonse Veno, repairman, Wisconsin Telephone Company, Ashland, Wis.

Keziah Elizabeth Weaks, night operator-in-charge, The Bell Telephone Company of Pennsylvania, Hatboro, Pa.

Etta Willcox, night operator, Northwestern Bell Telephone Company, Williams, Ia.

Commenting upon the cases which it had considered in deciding the awards, the committee said, in part:

"The fine spirit which prevails among the men and women of the Bell System has again been evidenced by the reports which the Committee of Award has had before it. Again it is clearly seen that loyalty and devotion to public service and disregard of self are the rule rather than the exception.

"The Theodore N. Vail medals are intended to give special recognition to some of the outstanding acts which reveal the spirit and typify the performance of Bell System employees in the service of the public.

"In the award of gold and silver medals, the Committee has, with the greatest difficulty, selected from many worthy acts a few which from every point of view are conspicuous instances of this universal spirit, and has given consideration only to acts in the line of duty.

"The many acts of heroism and self-sacrifice on the part of telephone people while not engaged in telephone service, and for this reason not given special awards by this Committee, nevertheless are inspiring proof that the loyalty and devotion to the public which was Mr. Vail's ideal, finds expression in the daily life as well as in the work of the System's employees."

Abstracts of Recent Technical Papers from Bell System Sources

Thermionic Work Function of Tungsten,¹ by C. Davisson and L. H. Germer. The relation between thermionic current and temperature known as Richardson's Equation is derived by a thermodynamic argument. The failure of this argument in any one of several of its assumptions might lead to an incorrect estimate of the thermionic work function calculated from the b of Richardson's Equation without necessarily effecting the appropriateness of the equation to represent the temperature-emission relation. Thus there is some theoretical importance attached to a direct comparison between values of the work function obtained from temperature-emission data and those obtained calorimetrically.

The authors have carried out a careful experimental determination of b by both methods on the same sample of Tungsten and find a difference of 2.7% between the two methods, a difference believed to be greater than the probable error of the experiments. It is pointed out that if the thermionic energy of conduction electrons within the metal is taken to be zero instead of $3/2kT$ of the classical theory, the two values of the work function agree within the probable error of the measurements. Work done by the authors, subsequent to the writing of this paper, leads them to another explanation of the difference which will be discussed in a later paper.

A Method of Maintaining Small Objects at Any Temperature Between -180°C and $+20^{\circ}\text{C}$,² by P. P. Cioffi and L. S. Taylor. By methods described in this paper, any small object may be maintained for many hours at a temperature which does not vary by more than 4 degrees within the range above indicated. The methods do not lend themselves to abstracting.

¹Physical Review, Vol. 20, page 300, Oct. 1922.

²Journal of the Optical Society of America and Review of Scientific Instruments. Vol. 6, page 906,²Oct. 1922.

*Passage of Hydrogen Through Quartz Glass,*¹ by J. B. Johnson and R. C. Burt. The rate of flow of hydrogen through quartz glass has been measured over the temperature range of 300° C to 900° C. Measurements were also made with nitrogen and argon. Perceptible diffusion starts with hydrogen at about 300° C and with nitrogen at about 600° C, and then in each case increases rapidly with the temperature. The volume of diffusing gas varies approximately inversely with the $3/2$ power of the molecular weight which is in agreement with the view that diffusion occurs through very fine holes or tubes in the material. The increase of diffusion, however, varies as the third or higher power of the temperature rather than as the square root of the absolute temperature which this explanation would require. Diffusion begins at the temperature at which structural changes are known to occur in crystalline silica and this fact suggests that the passage of the gas may result from a modification in the structure of the non-crystalline material.

*Physical Theory of the Electric Wave Filter,*² by George A. Campbell. The electric wave filter is one of the most important of present day electric circuit developments. It makes possible the separation of broad bands of frequencies into narrow bands in any desired manner, effecting the separation much more sharply than tuned circuits. The filter stands beside the vacuum tube as one of the two devices making carrier current telegraphy and telephony practicable, and it also forms a part of every telephone repeater set. Moreover, it is finding many applications to radio.

The present paper is the first of a series on the electric wave filter to appear in the Bell System Technical Journal. Being an introductory paper, the author discusses his subject from a physical, rather than mathematical point of view, the fundamental characteristics of filters being deduced by purely physical reasoning.

¹Journal of the Optical Society of America and Review of Scientific Instruments. Vol. 6, page 734, Sept. 1922.

²Bell System Technical Journal, Vol. 1, Nov. 1922.

Binaural Location of Complex Sounds,¹ by R. V. L. Hartley and T. C. Fry. Much has been written on the binaural location of pure tones but the case of complex sounds has received little attention in recent literature. The purpose of the present paper is to bring the discussion of complex sounds abreast of that relating to pure tones.

The paper virtually assumes that the location of complex sounds involves three processes, first, the resolution of the sound into its component tones; second, the independent (generally subconscious) location of each separate component; and third, the formation of a conscious judgment of the position of the source based upon the locations of the individual images. The greatly increased amount of data available when sound is complex has different effects on the final result, according as the different images do or do not coincide. If they do, the accuracy of location and the sense of certainty are increased; if they do not, confusion arises, subconscious corrections are called for, and the final result is likely to depend very considerably on the psychological processes and individual prejudices of the particular observer.

The Heaviside Operational Calculus,² by John R. Carson. The art of electrical communication owes a great and increasingly recognized debt to Oliver Heaviside for his work in developing and emphasizing a correct theory of electrical transmission along wires and in particular for his insistence on the importance of inductance. His operational methods of solving the differential equations which are fundamental to the theory of electric circuits, although not widely known, are important. These methods are peculiarly applicable to many important problems of electrical transmission.

Briefly, Heaviside's operational calculus method is as follows: Problems in electric circuit theory are described by a set of differential equations involving the differential operator $\frac{d}{dt}$; these differential equations are

¹Bell System Technical Journal, Vol. 1, Nov. 1922.

²Bell System Technical, Vol. 1, Nov. 1922.

reduced formally to algebraic equations by replacing the differential operator by the symbol p and by this expedient a purely symbolic solution is obtained. This symbolic solution is called the operational formula of the problem.

In order to interpret the purely symbolic operational formula, Heaviside proceeded as follows: by direct comparison of the operational formula of specific problems with their known explicit solutions he assigned a definite significance to the operator p . Thereupon, he obtained by induction generalized specific criteria or rules for solving the operational formula.

The present paper, by attacking the problem from a different standpoint, shows that the Heaviside operational formula is a shorthand equivalent of an integral equation from which the methods and rules of his operational calculus are deducible.

The Physical Characteristics of Audition and Dynamical Analysis of the External Ear,¹ by R. L. Wegel. This paper discusses some of the characteristics of the ear which have become important in the design and development of telephone apparatus and circuits. The field of audition, bounded by the curves of minimum and maximum loudness as functions of frequency, has been determined for a large number of ears, and the smaller included area most used in speech has been mapped. The nature of these fields in certain cases of abnormal hearing has also been determined and the conditions which must be observed in designing apparatus to satisfactorily relieve deafness are discussed.

The sensitivity of the ear is given in terms of the *r. m. s.* pressure measured by a calibrated condenser transmitter. It is pointed out that this pressure is not necessarily equal to that which, when applied to the ear drum, would just give rise to the sensation of sound. However, it is the nearest approach to the value of this pressure which can be determined at present, and as the dynamical properties of the ear become more fully known

¹Bell System Technical Journal, Vol. 1, Nov. 1922.

it is shown how the relation between the two pressures can be more accurately stated.

The Relation Between Rents and Incomes, and the Distribution of Rental Values,¹ by W. C. Helmle. Many parts of telephone plant, such as central office buildings and equipment, conduits, underground and aerial cable, at the time of installation must have the capacity to handle not only the immediate demand for telephone service, but also that for a number of years to come. The plant engineer such items of telephone plant economically necessary to know in advance as accurately as possible what the demand for telephone service will be in five, ten, or twenty years in the future. Forecasts of the future market are very necessary for plant engineering, operating plans, rate treatment, and other purposes, in multi-central office cities. In such cities detailed estimates are made of the market some twenty years ahead and of its telephone development under stated rate conditions. Such estimates are called commercial surveys, and they involve a study of the various factors which, in the course of events, will be likely to control the industrial, commercial and residential development of the city concerned.

In the course of such a survey, a rental classification of all families is obtained and at the same time a record is made of existing telephone service in each rental class. The rent data of this article have been gathered in representative large cities throughout the country and the results as here set forth are being used together with many other kinds of data to guide the engineering of future additions to the plant of the Bell Telephone System.

In general the income of a family is an index of the market it creates for various commodities including telephone service. Rental values may also be considered as such an index and the present study seeks to correlate rents with incomes. Rents can be readily recorded and classified, whereas it is not feasible to determine the money incomes of large numbers of families. While it may be ideally possible, by a study of rent data, to com-

¹Bell System Technical Journal, Vol. 1, Nov. 1922.

pare the inherent markets for telephone service and also the strength of the telephone habit in various cities, there are many practical limitations to such a procedure. Comparison of the residence market for telephone service in different cities, as determined by rent values, is made difficult by the fact that the variation between cities in rentals paid for substantially similar dwellings is considerably greater than the variation in prices for food or clothing. Further, there is considerable variation in rent levels even in different sections of any one city. Attempts to compare rent distributions by application of the usual statistical measures of dispersion and skewness have proved unsatisfactory. However, a method of charting has been found by which rent distributions may be readily compared with one another and an index of spread or dispersion determined. It has been found that cumulative curves of rent distribution may be plotted on logarithmic probability paper to yield straight lines for a large number of cities. These are called logarithmic skew distributions. Although it has not been found possible to assign any special significance to the particular value of the index of rent dispersion in any city, this index appears to remain practically constant for that city regardless of changes in the level of prices. In the appendix the mathematical features of the logarithmic skew curve are discussed.

Power Losses in Insulating Materials,¹ by E. T. Hoch. It is shown that a satisfactory measure of power loss in a dielectric is the product of phase angle and dielectric constant. Although the dielectric constant need not be explicitly considered in the design of condensers, it is important in such cases as the design of apparatus panels, and vacuum tube bases. The method used in measuring phase angle and dielectric constant is discussed.

Application to Radio of Wire Transmission Engineering,² by Lloyd Espenschied. This article points out that

¹Bell System Technical Journal, Vol. 1, Nov. 1922.

²Bell System Technical Journal, Vol. 1, Nov. 1922. Also printed in the Proc. Radio Institute for October, 1922.

radio and wire communication systems are subject, fundamentally, to the same general requirements, and its purpose is to develop for radio, points of view which are familiar to wire transmission engineers. The transmission characteristics over a wide range of distances are compared. For short distances the comparison is favorable to wires. Although over great distances, the advantage of electric waves, guided by wires, may be less than the unguided waves of radio, it is pointed out that at the present time intermediate amplifiers can be more economically applied in wire transmission than in radio to boost the message energy. Economy of transmission requires the handling of messages at as low an energy level as possible, and, as the author points out, wire transmission satisfies this requirement much better than radio. Referring to the transcontinental line with radio extensions, which was used recently to talk from Catalina Island in the Pacific Ocean to a ship in the Atlantic Ocean, it is stated that had all of the necessary energy been introduced at one end of the circuit, there being no intermediate amplification, the total power required would have been 1.8×10^{29} kilowatts, an amount unavailable in the world. In the actual system distributing the amplification along the transmission line, the power required sums up to something less than 1 kilowatt.

Interference between messages and extraneous disturbances is discussed, and the requirements involved in keeping message energy well above the energy level of the disturbances in both systems are pointed out. The limitations on two-way operation resulting from "singing" of the entire system are considered for both cases and for combination wire and radio circuits as well. The method of improving the efficiency of transmission by suppressing the carrier and one side band is discussed. Finally the factors involved in obtaining high grade quality of transmission are enumerated.

A Low Voltage Cathode Ray Oscillograph,¹ by J. B. John-

¹Bell System Technical Journal, Vol. 1, Nov. 1922. Also published in the Journal of the Optical Society of America and Review of Scientific Instruments, September, 1922.

son. A sensitive cathode ray oscillograph is described which operates at the low potential of from 300 to 400 volts. The electron stream comes from a thermionic cathode and is focused by the action of ionized gas in the tube. This gas, at a pressure of a few thousandths of a millimeter, serves to reduce to 1 mm. diameter a spot which would be 1 cm. across in a high vacuum tube. The geometry of the tube is such that the deflection of the spot is about 1 mm. per volt applied between deflector plates. When using magnetic deflection, a pair of coils 4 cm. in diameter placed on the sides of the tube produces a deflection of approximately 1 mm. per ampere-turn of the coils.

The Theory of Probabilities Applied to Telephone Trunking Problem. by E. C. Molina. For years, it has been known that light could be shed on many problems of telephone engineering by the application of probabilities. This has been particularly true since about 1905, when the development of machine switching systems arrived at a stage where the relative efficiencies of different sizes of trunk groups became of prime importance. Machine switching developments, therefore, gave a great impetus to the application of the theory of probabilities to telephone engineering. This paper discusses certain simple trunking problems, reducing each to an equivalent dice problem, so that they can readily be handled to a sufficient degree of approximation by well known probability methods.

*The Resolution of the Ka Doublet in the Powder Method of X-Ray Crystal Analysis,*² by L. W. McKeehan. Crystals of sufficient size give rise to diffraction images of the source of X-rays, which may be double in cases where two nearly equal wave-lengths are present. Two types of such doubling are distinguishable. In the first and more important type, the angular separation of the images is dependent only upon the difference in wave-length and the mean deviation. In the second type,

¹Bell System Technical Journal, Vol. 1, Nov. 1922.

²Journal of the Franklin Institute, Vol. 194, pp. 87-92, July, 1922.

which is often the more conspicuous, the relative positions of the source, sample, and photographic film are also of importance. The characteristics of both types are described and illustrated by photographs. The phenomenon permits very accurate measurement of wave-length differences and consequent determination of the fine structure of intense lines in the X-ray spectrum.

*The Crystal Structure of Potassium,¹ *The Crystal Structure of Beryllium and of Beryllium Oxide,² *The Crystal Structure of Silver-Palladium and Silver-Gold Alloys,³ by L. W. McKeehan. The first two of these papers are short notes presenting the results of X-ray analysis on two elements not hitherto successfully examined, and on an oxide of one of them which occurred as an impurity of the metallic sample employed. Potassium is similar in structure to Sodium being built on a body-centered cubic space-lattice. Its crystal structure is only measurable at low temperatures. Beryllium and its oxide are of the same crystal types as zinc and its oxide. The lightness of beryllium and the simplicity of its electronic structure make the results particularly interesting to students of sub-atomic problems. The last of the three papers is concerned with the gradual changes in the space-lattice of a metal when another metal, soluble in all proportions in the first, is introduced. At least for the pairs studied so far, the changes in dimensions of the unit of structure are directly proportional to the amount of the second metal. Otherwise expressed, the variation in inter-atomic distance, measured between atom-centers, is linear in composition. Alloys of exceptional electrical or mechanical properties vary slightly from this rule. The effects of annealing and cold working are, in some cases, easily observed.***

¹Proceedings of the National Academy of Sciences, Vol. 8, pp. 254-255, August, 1922.

²Proceedings of the National Academy of Sciences, Vol. 8, pp. 270-274, September, 1922.

³Physical Review, Vol. 20, pp. 424-432, November, 1922.

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Some Matters Relating to Depreciation

EVERYTHING is simple if you understand it. What makes things seem complex is the lack of this understanding. It is not too much to say that the misapprehensions as to the subject of depreciation may be ascribed very largely, if not almost entirely, to a failure to appreciate a few very simple factors which are fundamental to this matter, so that they very largely control sound conclusions with reference to it. It is my purpose to state some of these fundamental propositions which are so simple that they may almost be said to demonstrate themselves, and to call attention to some of the most obvious deductions from them.

First: It is a recognized established fact which cannot be disputed, that in the rendition of telephone service sooner or later from one cause or another—wear and tear, obsolescence, public requirements, storms, or what-not—the telephone plant is used up, except a few classes of so-called non-depreciable plant such as land.

Second: It is self-evident that the cost of the plant so used up in rendering the service, less such amount, if any, as is recovered as net salvage when the plant is taken out of service is a part of what it has cost the company to furnish the service. It is equally clear that this expense item—this cost of plant used up—must be allocated to the period during which the item of plant in question has

been in service, that is, to the period of its useful life. It is a part of the cost of furnishing the service during this period. If an automobile, used up in five years of service, has cost \$2,000 and returns \$400 in net salvage, then the remaining \$1600 is a part of what it has cost the company to render the service during this five-year period. If a switchboard is used up in fourteen years in the rendition of the service, its cost is a part of the cost of rendering the service during that period. Illustrations might be multiplied indefinitely.

Stating it generally, the cost of plant used up in rendering the service, less net salvage, if any, is a part of what it has cost to render that service while the plant in question is being used up.

Third: This being true, the conclusion is inevitable that if the operating accounts of the company are to correctly reflect the cost of rendering its service, there must be taken into these operating accounts, as a part of this cost, this expense on account of plant used up. The \$1600 on account of the automobile must be charged to operating expenses during its five years of useful life, and the cost of the switchboard, less salvage, must also be so charged during its useful life of fourteen years in order to make the accounts show the actual cost of transacting the business.

This conclusion is as inevitable as that two and two make four. As soon as it is recognized that the cost of property used up is a part of the cost of doing the business, the conclusion inevitably follows that this expense item must find its way into the accounts as an operating expense if they are to correctly reflect the facts as to the business.

These are the simple fundamental propositions. A part of the expense of rendering the service is the cost of property used up in its rendition. Because this cost is a part of this expense it must appear in the accounts which show this expense, that is, as a part of the operating expenses.

What distinguishes an operating expense of this kind from the ordinary operating expenses is the fact that because the property is used up slowly the expense for the item in question covers more than one accounting period. This does not affect its essential character as an expense incurred in the transaction of the business. It is only material in the determination of how and when this expense should be brought into the accounts.

THE ACCOUNTING PRACTICE

When should this expense be brought into the operating accounts? Obviously, during the period when the expense is being incurred, that is, during the period when the item of plant in question is being used up. Because the expense is incurred during this period it must be shown in the operating accounts for the same period. Otherwise, they would not truly reflect the operating expenses for this term.

Sound accounting requires that this be done by charges to operating expenses in equal periodical increments. It is unnecessary to present the arguments which support this accounting practice. Its soundness is recognized by the Uniform System of Accounts prescribed by the Interstate Commerce Commission and by the laws of numerous states which require it.

Three factors must be determined in order to fix the amount of the monthly charge to operating expenses on account of any item of plant which is being used up in rendering the service. They are its cost, its useful life and the amount of the net salvage which will be realized when the item of plant in question is retired from service. The cost factor presents no difficulties. It is a known amount to be ascertained from the books. The useful life and the amount of net salvage may not be fixed with the same precision, because they look to the future; they have not yet occurred as facts, and so of necessity must be estimated. Just as a life insurance actuary cannot predict the life of any particular individual, a telephone

expert cannot predict with certainty just when any particular item of plant will go out of service; but like the life insurance actuaries, those who have charge of these matters for the telephone companies can from their experience and the statistical and other data available determine the average useful life of the various classes of items that go to make up a telephone plant. So that this factor of useful life is a determinable factor which may be and is fixed with what is reasonable accuracy for all practical purposes. And what is true of this factor is also true as to the remaining factor of net salvage.

These factors having been ascertained, the balance remaining after deducting the net salvage from the original cost is the expense which remains to be taken into the operating expenses on account of the item of plant used up. How much should be so charged in each month becomes then a simple question of arithmetic. For instance, if a switchboard has a useful life of fourteen years and the net salvage is, say 30 per cent, there remains 70 per cent which represents this cost to be charged to the operating expenses during the fourteen years, which means 5 per cent in each year, or $5/12$ of 1 per cent each month.

In passing, it is worth while to note that there is nothing anomalous in the way this expense item is treated in the accounts. All expense items covering a period of one year or more are treated in the same way, such as taxes, insurance, bond discounts and expenses of financing. In each of these cases the amount of the expense for the period is determined, as for instance the taxes for a year, and each month the proper proportion of it is charged to operating expenses and credited to an account against which the payment is charged when the expense item matures. To illustrate, if it is expected that the taxes for a year will be \$1,200,000, each month \$100,000 is charged to expenses and credited to the account called "Taxes Accrued." Then as the taxes become due they are paid, and the payments are charged against this account. In these accounts, as in the account "Reserve

for Accrued Depreciation," no special fund is actually maintained among the assets. The amounts credited to these accounts remain in the general funds of the company and are used for its general purposes. When payments are made, the money is taken out of any general funds available, and the reserve account is charged.

THE ACCOUNT "RESERVE FOR ACCRUED DEPRECIATION"

This account is a piece of accounting machinery which facilitates charging the cost of property used up to operating expenses in equal monthly installments, instead of in lump sums, which would unbalance the accounts, and which provides for taking out of the capital accounts the cost of property retired from service.

While the account shown upon the books is entitled "Reserve for Accrued Depreciation," as has been indicated, no reserve in the sense of a particular fund set aside for this specific purpose is maintained. The cost of property used up, less the net salvage, is taken care of by monthly charges to operating expenses. To offset these charges, monthly credits in like amounts are made to this account called "Reserve for Accrued Depreciation." The money represented by these entries comes out of earnings; it does not, however, go into a separate fund. It goes into the general funds of the company, and through them finds its way into property and plant owned by the company, so that as items of plant are used up and retired they are replaced by other investments in like amounts. In this way the capital is maintained unimpaired.

It is a misconception to think of this reserve in the sense of funds set aside and earmarked for use only in payment for replacements. The system of accounting does not contemplate such a fund. What is done is not to set this money aside and thereafter put it into the plant through replacements paid for out of this particular fund. What is done is to take this money out of earnings and at once put it into additions to plant, so that by the time the original plant in question is displaced there will

have been added to the plant additions costing a like amount.

REPLACEMENTS DO NOT MEASURE DEPRECIATION
CHARGES

What has preceded demonstrates that the amount to be charged to operating expenses on account of depreciation is measured, not by amounts spent in replacements, but by what has gone into the property and has been used up. Renewals have nothing to do with the matter. Whether any renewals are made or not, and their amount, do not in any way affect this expense item.

To digress for a moment, it may be noted that in the telephone industry property displaced is rarely replaced by property exactly like it. Additions to plant most frequently are not in the form of replacements of property taken out of the plant, but are usually made up of property that differs from that displaced. Pole lines of greater capacity are constructed in lieu of those abandoned. Cables are substituted for open wire; conduits for pole lines. Larger switchboards, or switchboards of different types are constructed, and so on through the list.

Returning from this digression, if it is borne in mind that this charge is an operating expense on account of property used up, it must be absolutely clear that the statement that what determines its amount is the property used up, and that renewals have nothing whatever to do with it, is entirely sound. If an automobile is used up in the rendition of the service, then this cost has been incurred and is absolutely unaffected by whether this automobile is ever replaced by another one or not. The using up of the property creates this expense and determines its amount; whether anything is done, and what is done in the way of replacing this property or substituting other property for it are absolutely immaterial. If a switchboard is used up in the service, the fact of the expense and the amount of the expense are inevitable. The amount of this expense cannot be made greater or less by

any considerations except the original cost of the switch-board used up and the net salvage. When the switch-board is retired from service, its cost less the net salvage is a cost incurred in rendering the service, and this cost is unaffected by any other factors.

Therefore, the things to look to in determining the amount of the charges to operating expenses on account of property used up are solely its cost, the net salvage and the useful life. With these factors correctly determined, the amounts of these charges must inevitably be correct, because they will equal the expense incurred on account of this property used up. If they do equal it they are right and the amount credited to the account "Reserve for Accrued Depreciation", whatever it is, is right; if they vary from it more than the variation which sound business prudence permits in dealing with an item that cannot be ascertained with absolute accuracy, to the extent of this variation they are wrong, whatever the credits in the reserve account and whatever the current charges against it.

THE TRUST FUND THEORY

It has sometimes been asserted that the amounts set aside to cover these expenses and the property in which they are invested are impressed with some kind of a trust, so that they are not in fact the property of the company. The fundamental matters to which reference has been made fully demonstrate the unsoundness of such assertions.

The amounts in question are set aside out of the company's earnings. It is a loose and inaccurate way of thinking to assume that its subscribers pay to the company specific amounts to be devoted to this depreciation account. They do not, any more than they pay to the company amounts to be used specifically for taxes or insurance or operators' wages, or any other expense which it incurs. Its patrons receive service from the company; what they pay to the company is paid for this service.

It is not paid on account of any or all of the company's expense items. This money belongs to the company because it has earned it, for exactly the same reason that what any man earns belongs to him.

The obligations which the company incurs in the transaction of the business are its obligations—the obligations of the company, and not of its patrons. Whether the company has revenue or not, and the amount of its revenue, in no way affect its obligation to meet its expenses. It must pay its employees, it must pay its taxes, it must pay its insurance, and so on throughout the list, whether its revenue be adequate or inadequate, great or small.

The company sets aside a part of its revenue to provide for the expense arising because of property used up in furnishing its service. The money so set aside belongs to the company because the company earned it. It uses this money in the purchase of additional property, so that as property goes out of the plant new property comes in, and its capital is maintained unimpaired. This new property is the property of the company for the fundamental reason that the company bought it and paid for it with its own money. There is nothing better settled than that what one buys and pays for out of his own earnings is his.

Any other conclusion would destroy the investment of the company. As each \$100 of plant is used up the company provides another \$100 of plant to maintain its capital unimpaired, but if this second \$100 of plant did not belong to the company but belonged to someone else, then when the original plant was used up the capital invested in it would be gone.

Its original plant belonged to the company because it bought it and paid for it with its own money. Additions which it makes to its plant from time to time out of its earnings belong to it for the same reason. The assertion that these additions are not the property of the company but are impressed with a trust is neither good sense nor good law nor sound economics.

N. T. GUERNSEY.

Public Utilities as "Allies of Industry"

From the Address of Mr. E. K. Hall, at Chamber of Commerce Luncheon, Boston, Mass., March 1, 1923.

IN speaking of public utilities I mean all of the public service companies—the steam and electric transportation companies, the energy and light producing companies, and the communication companies. These companies are more than allies. They are the agencies around which and upon which modern civilization and business and commerce are built. They render a fundamental service. It is more than an allied service.

It is in the nature of a public service because they serve all of the public, either directly or indirectly. If these services were provided by governmental agencies, and they were all of them made one hundred per cent dependable, just what the public needed everywhere and at all times, we would have a basis for stability and prosperity in industry that this country has never seen. But it has been found that the government cannot furnish this service effectively because of changing administrations, lack of foresight, unwillingness to pick the best man for the job, political atmosphere and various other reasons. It has been demonstrated that it is utterly hopeless to expect to get this kind of service from governmental agencies.

Therefore, we have them in the form that we have them today—public utilities financed by private capital and not from the public treasury; managed by business men selected by the people who have risked their money and put it into the business; and regulated in the public interest by public authority. In other words, these agencies, these allies, are in the form of business corporations. And they are your allies, essential to the successful conduct of your business.

Now, what kind of allies do you want? You don't want weak, anaemic, crippled, halting, shrivelling, broken-

down, bankrupt allies. You want them strong, alive, dependable, on the job, progressive and growing. That is the kind of allies you want.

That means, talking in terms of business corporations, because that is what they are—that means prosperous corporations; that means prosperous public utilities. Now, a prosperous public utility is not the same thing as a prosperous industrial corporation; that is, we use a very different yard-stick to find out whether a public utility is prosperous than we do to find out whether an industrial concern is prosperous.

If we say that an industrial concern is prosperous, it generally means that in certain periods, or in prosperous times, that industry makes large, sometimes very large profits. Large enough in one or more prosperous years to fill the valleys of the lean years, and very often large enough so that after paying reasonable dividends, there are profits enough left to “plough” back into the business and build it up. Practically the entire growth of the business in a thoroughly prosperous industrial concern has often been provided by the excess profits from the business itself. The Ford Motor Car Company is a conspicuous example.

The public utility is not at all like that. A public utility never expects and never did expect in any one year or period of years to make large “profits” as you gentlemen in industry and commerce consider “profits”. All that the public utilities are entitled to get and all they are asking to get is money enough to pay their bills, to pay good, fair, reasonable wages to the men and women that are giving the service, good, fair, reasonable wages for the capital that is making the service possible, and just one thing more—a reasonable margin over and above that every year. Not a big margin, not a margin that will in itself provide for enlarging business in the future, but just margin enough to give a sufficient cushion of safety to maintain beyond question the credit of the public utility. That is all they ask, just that reason-

able margin which, measured by any yard-stick that you gentlemen use in your business, is a narrow margin, a very narrow margin.

Now, prosperity is a word we all like to use. It indicates health and growth and progress and action and life. We do not hesitate, any of us, to say "See the textile industries of New England! They are prosperous, and it is a good thing for New England that they are prosperous." "The leather business is coming back into prosperity again and it is a fine thing for New England." "The fish industry is prosperous. It is a good thing for the state." I suppose there is not a town in the United States where the people do not like to say "Look at our bank. It is a prosperous bank. It is a great asset to the community." We are delighted when we see reports of the great agricultural industries of the country and learn that they are prosperous. We like the sound. It makes us feel good. It's a good sign. And so in the mining industry and the steel industry, and any other. But how many of you ever heard people going up and down the street enthusiastically saying, "We have nothing but prosperous utilities in this town. We have prosperous railroads in New England. Isn't it great?"

Why is it? Why aren't we glad to say, "Here is a prosperous utility?" Well, I don't know. There are not a great many of them about which you can say it, anyhow. But I think it is because of an erroneous impression that somehow or other, if the utilities prosper, they prosper at the expense of the public. Now, nothing could be further from the truth. If the utilities prosper, they never prosper at the expense of the public. But if they *fail* to prosper, it is *always* at the expense of the public. If a public utility fails to prosper its stockholders may suffer inconvenience or even hardship. Perhaps they can stand it if they have to. We have seen many cases where they did stand it and live. The lack of prosperity may go to a point where the employees suffer

to some extent, but the public always suffers if the utilities fail to prosper.

So, the first point I want to make is this: If you want your utilities to work for you, make them strong; that is, make your utilities prosperous and keep them prosperous! And that means that you will be getting the service you need today and you will be guaranteeing your service for tomorrow, and for next year and for five years from now and ten years from now.

One of the most conclusive pieces of evidence as to the value of the service of these utilities to industry and commerce and to society at large lies in this fact, that the demand for these services, all of them, transportation, power and light, telephone, telegraph—has increased and today is increasing much faster than the population increases, very much faster. I hope you will pardon me if I use my illustrations from my own utility. That is the one in regard to which I know the facts. I am speaking for all. The principles underlying all are the same.

Since 1900, the population of the United States has increased 37 per cent. You would naturally expect that the demand for telephone service would increase somewhere around 37 per cent. During that period the demand for telephone service has increased, not 37 per cent, but over 1000 per cent, or tenfold since the year 1900. This increase is mainly accounted for by the demand created by greater industrial activity.

That demand on the part of the public for more service cannot be met by going out and employing more people. If it could be done that way, it would be easy. It just does not work that way, that is all. It is true that we must get more people, but we must get the appliances for them to work with first. Before we can begin to give that service, we must construct the plant and install the equipment without which these utilities have no facilities for rendering service.

I wish I could make this point clear to you gentlemen, because it brings up the problem that is less understood

and more misunderstood on the part of the public than any other one thing in regard to the utilities. That problem is this continual demand—that you create and that we have to meet, if we can meet it—for more, better, and different service.

It does not look very big when you take it up in small units. You see the electric light company running a cable along the street. It does not occur to you that is very much of a program. You happen to know that in a certain city they are putting in hard pavement on certain streets, and the electric light company and the telephone company have to abandon their over head wires and construct a new cable system underground. You say that it is a good thing, it improves the looks of the street. Then there are new wires here, a new switch-board, an enlarged power plant, a new siding here, a new station there and all that sort of thing. No single item looks very large, but when one comes to add them all up together the total runs into money that almost staggers one.

Let me just illustrate. This is a simple looking object that I hold in my hand. It is a section of a telephone cable. It looks like a bunch of wires bound together and wrapped around with lead. That is a section of aerial telephone cable that is under construction now from New York to Chicago. When it is completed, you are going to use it. It is going to insure your service from the East to the West. Those Lake sleet storms are not going to interfere any more with your conversations between here and the West unless the poles go down. You probably agree it is a good thing. What do you suppose it will cost? It has been three years in building. It will take another year to complete it. When it is completed, from New York to Chicago, with all the appliances, loading coils, relays and other delicate apparatus necessary to make it work the way you want to have it work, it is going to cost \$35,000,000—just that one cable from New York to Chicago.

Another illustration, if I may take it from my own utility. I have explained that it is no use to employ more people to give you more service, when you want more service, until we first get tools for them. When we take on one additional employee, we have to put out \$6,000 to get him tools before he can go to work. Or to state it with strict accuracy our average investment for plant per employee is about \$6,000.

In the Bell System, we are planning to spend this year in new money, for additional plant which you people have already indicated you need for your service, close to \$150,000,000 and as far as we can see, the same program will be required for the next four years without any diminution and possibly with some increase.

The people in the power and light industry estimate that what they need in the year 1923, if they do the job right and provide service that you people are ready to use, if you could get it, would mean not a nickel less than half a billion of dollars. I do not dare try to tell you what it would mean in the transportation industry, street railway and steam roads, for they have been held back so long. I do not know what it would mean. It would stagger us all if we could know what those figures are and what this country really needs from the utilities.

Now here is a point I want to make very clear, if I can:—that by the very nature of the public utility business it requires perfectly tremendous capital investments. I think in all of the utilities it is now well in excess of fifty billions of dollars. That is an almost unthinkable amount of money. Think of fifty billions of dollars permanently invested in your industries or in the commercial concerns of the country and try to visualize the progress you would make with that amount of capital, provided you also had the market. But you must remember that you turn over your capital two, three, four, or six times a year. Do you realize that in the public utility business it takes two or three or four or, in some

instances, five years, before the capital is turned over once? In other words, one of the features of the public utility business is the tremendous capital outlay that it requires as a permanent investment—not temporary borrowing and temporary capital, but permanent investment. The enormous amounts of fixed capital required and the necessity of continuous additions to that capital are features of the public utility business, around which lies one of its greatest, if not its greatest problem.

This new money does not go in for the purpose of making more money for the people that have already invested their money in the business. This new money is not to enhance the value of the property for the people who are already investors, but it is to take care of the additional service which you people are calling for. It is not to increase the present profits, as it would be expected to do in an ordinary concern, but just to carry on; to do the job as the community demands it.

When these utilities call for this capital to enlarge these plants to take care of your growth and your future business it is important to every industry and every business concern in this country that they get it. It is infinitely more important to you than it is to the utilities that they get it. What does their getting it depend on? It depends on credit. What does credit depend on? Assuming reasonably efficient management, it depends on that margin I was talking about—just a good, fair, decent, able-bodied margin or surplus or cushion to come and go on. That is all. Keep that margin there and their credit will be safe. But it must be there every year. Not a skimpy one this year and a fair one that year and red figures the next year but always the steady margin. It does not need to be large. It is a pretty narrow margin, as margins go. But if it is reasonable and continuous, then the necessary capital will come to the public utilities as needed.

I am not talking about bond capital. I am not

talking about companies financing themselves through bonds. Any concern can finance itself through bonds until it has got everything it owns in the pawn shop—then it is through. I am talking about real credit. I am talking about the kind of credit that will bring money into the foundation of the financial structure of all these utilities, with the investor a partner in the equity.

Now, I hope that I have made this point clear:—that it is only by protecting the credit of your utilities today that you can make sure of your service of tomorrow. You cannot wait until you want that service and turn around and be sure of finding it at your elbow. Today you can insure it. Today you can make sure of your service five years from now. But it has got to be done today.

That margin in the public utilities is the index of whether you are going to get the kind of service you want and need in your business three, five and ten years from now. Industry can help itself in no way better than by protecting that margin, and that means by protecting the revenue of these utilities, its allies. I do not know of one single utility in the United States, in which it is safe today in the public interest to make any substantial general reduction in the rates and revenues. The only mistake that the utilities or the commission regulating the utilities can make in the question of revenues and rates is by having the rates too low. Revenues that are too high can, at best, be only slightly too high. The amount that they could be reduced is negligible, but the damage that can be done by rates that are too low, by destroying or impairing this margin that I am telling you about, is stupendous compared with any little apparent temporary saving to users that might be made by such reduction. Rates that are too high cannot do any harm. They will just preserve the strength of the utility, the strength of your allies, and there is

always opportunity to readjust them if they ever get to a point where, in the broad public interest, it is safe to reduce the margin.

It has been no simple matter for the railroads and the power and light companies and the gas companies and the communication companies throughout the United States to adjust their schedules, their revenues and their business, to the value of the dollar in this after-war period. We have all had difficulty in doing it. The job in many cases is not done yet. You have found it difficult in your business but for nobody has it been so difficult as for the utilities. The margins of even the reasonably prosperous companies are so small that it is not in the public interest to take any chances on impairing them.

Let us illustrate what those margins are. Last year in the Bell System, this margin that I am talking about, after paying all the wages, the bills and the dividends, and taking care of the depreciation of the plant—this margin was between twenty-four and twenty-five millions of dollars. Now, I do not know what you think about that for a margin. I do not know whether you think that is a fair margin or a narrow margin or a very excessive margin. Let us measure it. We have to measure it in the terms of the size and the responsibilities for service of the organization that has this margin. If the revenue of the telephone companies in the Bell System during the year 1922 had averaged one cent per telephone per day less there would not have been any margin or surplus whatsoever and the dividends could have been paid only in part. That is how big that margin is.

Is that a margin that anybody needs to be disturbed about? The only thing about that kind of a margin that needs to disturb anyone is that it is a margin that you cannot experiment with if you want enlarged or better or more dependable service next year and five years from now. And when I say that margin, I am talking about comparable margins in all the public utilities that have been able to adjust their affairs to the dollar of today and

establish anything approaching a safe margin—a margin that is safe for the public served by these utilities.

We must get it very clearly fixed in our minds that this question of relation between the public and the utilities in the matter of rates, is not a horse trade; it is not a case for jockeying—or cheese-paring or for either one to try to get an apparent, temporary advantage over the other. This relation between the public and the industries of the public utilities is a permanent, living relationship in which they must work along together for the benefit of each indefinitely from now through all time to come, and that is the only way it can be worked out to the advantage of industry, of commerce and of society.

My first suggestion was, keep your allies prosperous; my second suggestion is:—work with them. They are your allies. Work with them, not apart from them; not against them, but with them. The only job they have on earth, the only excuse for existing they have on earth, is to give you people and your industries service. All right. Get together with them and work out the way to get just the service you want. That is what you are entitled to; that is the only way that is going to be satisfactory to you or satisfactory to the utilities. So, I say, work with them.

Get acquainted with them. You will find out some things you do not know. You will find that some of you have been holding to impressions of 25 years ago. Twenty-five years ago you found some of the utilities doing things you did not like, so you said, "Let's regulate them." And you put them under regulation, and when you did it, you were in a retaliatory mood, and they resented it because nobody likes to be taken by the back of the neck and told, "Don't do that or you are going to get spanked." You did not like it even when you were four years old and you do not like it now. The utilities got a bit peevish 20 years ago when you talked that way to them. But get acquainted with them now and you will find they are not peevish. They know

more about their job than they did 20 years ago. They did not know very much about it then but most of them come pretty near understanding what it really is now. Most of them, you will find, understand that their job is service. You will find that they have accepted this idea of regulation and ask nothing else than that it be done intelligently and impartially in the real, permanent public interest.

You will find another change when you get acquainted with the utilities of today. In the old days when they were small and really just getting started, they were controlled by one man, by two men, or by a little group of men or a little clique, and it was easy for that one man who owned control or this little group of men to play the game for their own interest or their friends' interest and to think of their own interest before they did of the public interest. You will find that has practically disappeared. No one man controls any big utility. They are literally owned by the public and owned very largely, and increasingly so, by the people who are the users and the consumers of the service.

About the only exception to that proposition that you will find is the public utility which has failed to become prosperous and has gotten into trouble and has been taken hold of by the creditors. And I will say to you that when you get a utility in that shape—where the creditors have come in and are managing it—it is a mighty difficult thing for bondholders to look at the public interest first. Their first and controlling thought is to get their money back—they never dedicated their investment to a partnership with the public—they simply loaned their money and demanded collateral on which they propose to foreclose.

Another thing that you will find is that, almost universally, the utility managers recognize the fact that the public interest and their own interest are absolutely bound up and tied up together; that neither can prosper at the expense of the other; and that the public interest

in most cases is considered first. I have sat in a good many councils of a good many utilities during the last five years. I have been able to think of only one case where there was any suggestion by any manager or executive that the public interest was not equal to or to be considered prior to that of the utility.

I have a third suggestion:—make your utilities responsible. I want to emphasize this. Make them responsible and then hold them absolutely to that responsibility. How do you do with your own organization if you want a job done, and you call in your right-hand man? You say, "Here is what we want done. You have all the authority, no restrictions. You know the policies and standards in this organization. Go ahead and get results." He is pretty likely to come back with the results. You do not say to him, "Now that is what we want done but don't work on Fridays. Keep your left hand tied behind you and walk on one foot on Thursdays. Get John Jones to help you and don't accept help from anyone else. Don't spend more than \$14.20 on railroad fares and leave the office every night at 5:00 P. M." You put the sole responsibility on him.

The greatest single mistake that I know of that has been made in the regulation of utilities is the overzealous attempt—sometimes on the part of the public and sometimes on the part of the regulatory bodies—to take over a portion of the responsibilities of the management of the utilities. When you put the restrictions on and say, "You can't do it this way or that way, etc."—don't you see what happens? You create a situation in which your utility has an alibi. When they fall down and you complain, the utilities can and often very properly do say "We could have done the job, but you didn't give us a chance."

So I say, do not interfere with the management function. Put the responsibility for management upon the persons to whom it belongs and then you can hold them responsible. There are already too many cases in this

country where that cannot be done because the responsibility has either been taken away or divided.

Now, a fourth suggestion. These are your allies we are talking about. They are rendering you service. That is their job. What is the greatest incentive for gilt-edged service, service that is alive, active, with every pound of available energy behind it? What gets that kind of service? Not money. It is appreciation. Appreciation:—that is the greatest reward for service—occasional appreciation by the people who are being served.

Let me give you an illustration. Do you know what happens in a power and light company or a railroad or a telephone company when somebody writes in a letter and says, "Yesterday you took care of us in fine shape?" Do you think that letter goes into the waste basket? It does not go into the waste basket. That letter gets pretty nearly worn out just going the rounds and cheering up the gang—it keeps them on their toes for the next two weeks.

I can tell you how you could improve the quality of the service of any public utility in any community anywhere by ten to twenty per cent. Let the utility be giving just as good service as it is possible to give where there is never an expression of appreciation for the good service but plenty of complaint for the failures. Then let that community say, "You are all right, fellows. You mess it up once in a while, but generally speaking, you are all to the good and we are right with you." You will increase the quality of your service ten to twenty per cent, just by that, because you put real life and humanity into it.

Those are the four suggestions. But I hear somebody say, "Suppose we don't put any restrictions on these public utilities; suppose we do keep them prosperous; suppose we do try to work with them; suppose we do give them the responsibility. Then suppose they do not work; they just simply do not give us the service; they

just do not know their job. What are we going to do?" Well, if that should really happen, there are several things not to do. Do not do what has been done too often in the past. Do not try to cure it by reprisals. Do not try to do it by slamming them, by hurting them, by crippling them. The real answer is "It is not going to happen." Under the conditions I have just outlined, you'll be getting the service as you want it and there can be no alibis.

I am not suggesting to you gentlemen or to the public or to anybody else that you take over the problems or the troubles of the utilities. That is their job. It is not your job. You have troubles and problems of your own. What I am trying to suggest to you is how you can get from the utilities the service you need and must have if your industries are to be successful. There never was a truer statement in print than that made by this Chamber of Commerce in its announcement of this series of meetings, where it said, "Allies of industry:—The Public Utilities."

Allies of industry:—that statement goes right down to the root of the whole question. I know that the public utilities are absolutely ready for that alliance. I know that if the public, following the example of the leaders in industry and commerce, would accept and maintain that relationship as the true one between industry and commerce, and the public utilities, in five years we would see public service such as has never yet been seen in this country, nor any other. It would be in the interest of everybody. It could not be to the detriment of any living soul in the United States.

The way is clear. The formula is simple, and the principle is as sound as the granite hills. The formula is easy: Give your allies a chance. Make them prosperous. Make them strong. Do not cripple them. Do not let anybody else cripple them. Protect those margins. They are small margins at best, but they are yours—they are your insurance for the service of tomorrow. Keep

the responsibility for running the public utilities on the shoulders of the utilities, where it belongs. Do not give them the alibis to slide out with. Work with them and not apart from them, and give them an occasional boost.

I will tell you what that would mean. It would mean that all the capital that is necessary for all the service and every kind of service you want would simply flow into the utilities. And that would mean that the power and light companies of this country would go wherever it was necessary to go to the sources of power for electric energy. It might be to the distant water powers; it might be right to the mouth of coal mines. But if, alone or in cooperation with each other, they could finance the great construction programs to do it, they would go to the sources of the cheapest possible power, which is what industry is crying out for today.

What would it mean to the railroads? It would mean that by the year 1930, you would have—even for the greatly enlarged needs of the country in the year 1930—a quality of service approximating the kind of service that you had in 1900, and I do not dare try to tell you what could be done for industry by the communication companies under those conditions.

It would mean, furthermore, that all of these services would be more valuable and more dependable than ever before; that in proportion to their value all these services would be cheaper than ever before, and in many cases it would eventually mean that even the unit prices for the services would be cheaper. It would mean that the growth of the utilities would be more rapid than ever before, and, barring unforeseen world conditions affecting the United States, you would see a period of protracted, consistent and stabilized prosperity such as this country has never experienced.

E. K. HALL.

The Development of Cables Used in the Bell System

EARLY TYPES OF CABLE

THE principal earliest use of cable for telephonic purposes was where it became necessary to carry groups of wires across navigable rivers either by placing them on bridges, or in tunnels, or allowing them to rest on the bed of the stream. As gutta-percha and rubber had been used as the insulating materials in telegraph cables, it was natural that the first telephone cables should employ those materials. Single wire grounded lines were used and, to reduce overhearing from one wire to another as much as possible, each insulated wire had a thin metal covering which was grounded at intervals.

What was known as the Brooks System was also used to a considerable extent in the early days. In that system each conducting wire was covered with cotton and wrapped spirally with a very light copper wire, also insulated with cotton, to serve as an induction shield. The wires thus wrapped were bunched together and drawn into an iron gas pipe which was filled with oil. A stand-pipe and reservoir, containing several gallons of oil, was connected to the piping system for the purpose of maintaining the oil under pressure so as to prevent water from entering in the event of a leak in the pipe.

Some unique ideas came into more or less limited use during the first few years of the business. For example, there was a cable consisting of about 20 bare wires, each one drawn into a small glass tube. The group of tubes was then pulled into a lead pipe and a mixture of grease and rosin put in under pressure. When the lead pipe bent, the glass broke but the wires were said to have been kept apart by the compound holding the glass in place.

Overlapping the use of gutta-percha and Brooks cables came the introduction of cables insulated with rubber compounds and with cotton impregnated with paraffin.

Some of these were drawn into lead sheaths, while others dispensed with the lead sheath, using in its place coverings of water proof canvas or rubber tape.

In 1882, Mr. Vail was General Manager of the American Bell Telephone Company and his forward-reaching mind saw the necessity for investigating the feasibility of underground construction and seeking to overcome the difficulties, thereby brought about, in advance of the time when the growth of the business in the larger cities would require the wires to be placed beneath the streets. There were wide differences of opinion as to the extent of the transmission difficulties brought about by laying cables in the earth, and in order to obtain definite information on this point, Mr. Vail planned and caused to be carried out the first considerable experiment in placing wires underground, which was conducted, in 1882, by the American Company. Five miles of cable were laid in a trench between railroad tracks in Massachusetts. The trench was opened by means of a plow attached to a locomotive. After the cable was placed, a plank projecting from a car, acted as a scraper to push the gravel back into the furrow and bury the cable. The results obtained from this experimental installation were far from encouraging. Nevertheless, the work of placing wires underground went on and the following reference to it is made in the Annual Report of the Bell Company of March 28, 1883:

“In the work of putting wires underground the progress has not been as satisfactory as could have been wished. Underground cables have been laid in iron pipes in Boston in two directions from the main office, one line being 1,200 feet and the other 1,485 feet in length. Conversation is successful within short limits over these lines, but where they are used in connection with long lines—for instance those reaching to the suburbs—the voice becomes indistinct. Unless this difficulty can be removed, the connection with points outside of Boston would be almost,

if not quite, useless to those whose wires were underground. With our present facilities for experiments we can readily test the value of such improvements as may appear, and we hope to get more definite results before long in this direction."

The note of cheerful optimism thus sounded in the face of discouraging results is characteristic of the refusal to acknowledge defeat that has sustained and stimulated our technical staff in overcoming difficulties that would have staggered less stout-hearted and persistent workers.

A measure of the limited amount of cable in the early days is afforded by the statement, in 1887, by the General Manager of one of the largest Associated Companies, to the effect that "we believe it economical and desirable to have employees capable of doing all kinds of cable work, including joints and terminals, and have two men under instruction for that purpose."

While some use was made of twisted pairs in cables in the early eighties, not until about 1887 did it become clear that thereafter all cables should be manufactured on a metallic circuit basis. The use of metallic circuits followed the brilliant discovery of this principle by Mr. J. J. Carty, then a young man of 20, who first applied it, in 1881, in the case of overhead wires on the Boston-Providence line.

As late as 1890, the entire amount of underground wire in ten of the principal cities of the United States was equivalent to less than $2\frac{1}{2}$ days' output of the Western Electric Company's cable factory at the present rate of manufacture.

DEVELOPMENT ANTICIPATES GROWTH OF SYSTEM

By 1890, the production of trustworthy cable sheaths had reached a point where the use of cotton insulated, paraffin filled cables could safely be abandoned and the paper insulated, dry-core cable generally adopted. The use of paper insulation constituted an important advance in the telephone art. By 1892, the number of stations in

the Bell System had reached about 300,000, and the maximum of 100 pairs, then obtainable in the so-called "Conference Standard" type of cable, was becoming insufficient to satisfy the demands of the growing business. Cables with 150 pairs were speedily developed and 200 pair cables followed shortly. Further progress was to come with a decrease in the size of the conductor. By 1900, we had cables containing 300 and 400 pairs of No. 22 gauge wires and, by 1902, six hundred pair cables were being introduced into service.

At that time the Bell System was beginning to grow more rapidly than ever before. The year 1901 had witnessed the attainment of the first million subscribers' stations. The two-million mark was reached in 1904; three million in 1906; and four million in 1908. The need for more wires in a cable was again foreseen but, for a long time our experts were baffled in accomplishing this without too great a sacrifice in the transmission efficiency of the cable and in its electrical strength. The solution of this problem was reached in the 900 pair No. 22 gauge cable in 1912. It was rendered possible by the development of methods quite different from those which had previously been employed in cable manufacture. The experience gained in the development of the 900 pair cable enabled the new methods to be applied to still smaller wires and, after considerable further experimentation, it was found that 1200 pairs of No. 24 gauge wires could be made into a single cable. Concurrently with these developments came improvements in cables of No. 19 gauge wires for which there still remained important fields of use where the transmission requirements precluded the employment of the finer wire cables. In 1901, cables containing 300 pairs of No. 19 wires became available and, about 1918, the development of 450 pair No. 19 gauge cable was successfully accomplished.

There have been hundreds of millions of dollars expended for underground conduits and cables in the Bell System but, without these cable improvements, it would

have been necessary to multiply this sum many times to have afforded the facilities that are now available for the use of the public. Had these improvements not been made it is difficult to conceive how, in many places, the service could have reached its present magnitude.

LOADED CABLES

Loading was first applied, commercially, to circuits in a cable extending from Jamaica Plain to West Newton in the suburban district of Boston. The work was directed by General Staff engineers and the loaded circuits were placed in commercial service in May, 1900. In this installation it was necessary to use air-core coils, as suitable iron core coils had not yet been developed. The problem of designing and producing coils of the iron core type engrossed the attention of a group of some of the most highly trained mathematical physicists of the General Staff during the years immediately following the discovery of the loading principle. While development work on loading coils has continued up to the present time, the early work was particularly strenuous due to the novelty of the problem and the importance of being able to take advantage of the economies of loading at the earliest practicable moment. It was not until 1901, however, that toroidal coils were made which were suitable for use on loaded lines. In 1902, the loading of a cable extending from New York City to Newark, N. J., a distance of about 10 miles, was successfully accomplished. This was a No. 19 gauge cable containing 200 pairs, forty-nine of which were loaded at the outset. In the following year (1903), a 90 pair No. 16 B. & S. gauge loaded cable was installed between Boston and Brockton, a distance of about 20 miles. The notable thing about this cable was the use of staggered twists, consecutive pairs in each layer having twists of 5, $5\frac{1}{2}$ and 6 inches, respectively. This cable was found to be remarkably free from cross-talk and thereafter the staggering of the twists became the recognized standard practice.

These earliest examples of the use of loaded cables were quickly followed by the installation of many others, both for long interoffice trunks and for bringing open wire toll lines into cities. In New York loaded cables more than 15 miles in length replaced the famous West Street pole line. Cables for use with the longest open wire lines contained No. 13 B. & S. gauge conductors. In others, to meet less severe transmission requirements, No. 16 B. & S. gauge wires were used. A 90 pair, No. 16 gauge loaded cable, 44 miles in length, was placed in 1904 between Boston and Worcester. Soon, most of the largest cities had loaded cables, and additions were constantly being made.

The development of loading unfolded the possibility of placing in cable important groups of circuits connecting large cities at considerable distances from each other. By 1905 there was working from New York, in the direction of Philadelphia, a loaded cable 20 miles long. So rapidly was the art advancing that, in the following year, an underground loaded cable having No. 14 gauge wires was working successfully between these cities, a distance of 90 miles. The annual report of the A. T. & T. Co. for 1913 briefly sums up the situation as follows:

“By 1911 our experiments, researches and improvements in manufacture had so advanced that we were enabled to design an underground cable, capable of giving a satisfactory conversation between Washington and Boston.

“By 1912 a section of this new cable was laid from Washington to Philadelphia, there connecting with the earlier type of cable to New York.

“During 1913 a section of the new cable was laid between New Haven and Providence, connecting at New Haven to an earlier type of cable extending to New York, and connecting at Providence to an earlier type extending to Boston.

“While talking the entire distance from Boston to Washington was impossible through the old types,

yet by using the underground in connection with the overhead, the seaboard cities from Washington to Boston could be no longer isolated by storms destroying the overhead wires."

THE APPLICATION OF REPEATERS TO LOADED CIRCUITS IN CABLE

The year 1913 marked the development of the repeater to a point where it could be applied to the several loaded cables forming the chain connecting Washington and Boston, and satisfactory talks were had over the entire distance of 455 miles wholly in cable despite the fact that 47 per cent. of the total cable in the line was made up of types formerly suitable for short haul distances only. To the repeater, used in connection with loading, is due the extraordinary increase in the distance over which it is now possible to talk using circuits entirely in cable.

One of the characteristics of circuits in cable, if not properly loaded, is that they will cause increased attenuation in the voice current as the frequency rises. Due to this difference in the attenuation for different frequencies, speech may be rendered difficult to understand although the transmission may be loud enough for conversation to be carried on. Even though a sufficient number of repeaters were used in connection with a long non-loaded cable to give the desired degree of loudness at the receiving end, conversation would be difficult, for the reason that the higher speech frequencies would become more attenuated than the lower speech frequencies, and the repeaters would faithfully reproduce, with added volume, the speech distortion thereby brought about. The effect of loading is to bring about uniformity of attenuation for all frequencies within a range essential to preserve the characteristics of the voice. Thus it becomes possible to amplify over and over again the attenuated currents transmitted over properly loaded cables without appreciable sacrifice in the intelligibility of the speech. By the use of attenuation equalizers with repeaters, the speech

distortion could likewise be avoided, but, under ordinary conditions, the use of loading coils enables the desired results to be secured much more economically.

During 1921, a cable reaching from Harrisburg to Philadelphia, where it is available for connection with the Boston-Washington cable, was extended from Harrisburg to Pittsburgh. Plans are completed and work is already underway for extending this cable from Pittsburgh to Chicago. Improvements recently accomplished render it possible to talk over wires in cables 3,000 miles in length using conductors weighing but 80 pounds to the mile.

At the present time, in comparatively few parts of the country are the numbers of circuits along the same route sufficient to justify these special forms of cable. Although long continuous cables can, by means of loading and repeaters, be brought to a high efficiency, every effort still has to be made to keep long open-wire lines free from cable on account of the reactions on repeater operation of the electrical irregularities that would thereby be introduced.

To accomplish the successful use of repeaters a vast amount of work has been required in addition to the development of the repeating element itself. Electrical apparatus of a most refined and delicate nature and the complex circuits in which this apparatus is used have had to be invented and designed, and important changes have been required in many portions of the plant. Every step in the advance has been marked by patient research requiring electrical and mathematical knowledge and training of the highest order.

QUADDED CABLES

Following the discovery of the phantom circuit principle, about 1884, much work was directed toward applying the principle practically, both to open wires and to cables. Little success, however, was had in obtaining the extremely delicate and exact balances that were re-

quired both in the apparatus and in the lines themselves. The electrical properties of the circuits were not sufficiently well understood to enable the desired results to be attained and, for many years, phantoming remained scarcely more than an interesting scientific curiosity. As early as 1898, some experimental cable had contained a few wires spiralled in groups of fours, with the hope of obtaining workable phantom circuits. A cable extending between the Franklin and John Street offices in New York City contained three "quads" of No. 19 B. & S. gauge wires laid up in spiralled fours, all with the same rate of twist. The balance of the cable contained 115 pairs of No. 19 wires. So far as the phantom groups were concerned, cross-talk was so severe that they could not be used commercially. It was not until about 1904 that closed magnetic circuit phantom coils were designed and constructed having sufficiently accurate electrical balance to enable open wire circuits to be wholly successfully phantomed. The engineers of the General Staff, appreciating the desirability of phantoming circuits in cables, both to enable phantomed open wire lines to be brought into cities in phantomed cable and to attain the economies of phantoming in inter-city cables, addressed themselves to the problem of developing a practicable type of cable that would admit of phantoming.

A large amount of preliminary work was done to determine whether a phantom group of four wires should be spiralled or whether the wires should be twisted together in pairs, two by two, and the two resulting pairs twisted together. The cable which resulted from these early efforts gave so great mutual interference between each phantom and its side circuits as to prevent the use of such cable in commercial service, especially when the side circuits were equipped with loading coils.

The problem was attacked from two standpoints: first, to produce cable having the high degree of symmetry and electrical balance required to prevent mutual interference; second, to determine whether cables, insuffi-

ciently well balanced as they left the factory, could be installed in such a manner as to give satisfactory results.

It was in 1910 that the General Staff engineers produced the first practical loaded "quadded" cable by specially twisting together two pairs of wires to form what is now termed a "quad". This cable was installed between Boston and Neponset, a distance of about six miles. While the manufacturing processes employed in this cable were refined in many ways, the cable, as it left the factory, was not sufficiently well balanced to permit good phantom operation. After installing the cable, and before splicing it, the individual circuits were carefully measured for electrical balance. With the information afforded by these tests, the circuits to be spliced together were so selected that unbalances would be neutralized in adjacent cable lengths, thus producing a high degree of balance in the cable as a whole.

The results obtained were utilized in the cable placed in 1911 between Philadelphia and Washington, and since that time, every important inter-city cable has been so arranged as to permit of phantom operation.

The arrangement was, however, not wholly satisfactory, as the electrical balance was interfered with when cable lengths had to be replaced in the event of injury. It was found to be undesirable to rely so largely on this balancing during installation, and means were sought to enable the cables to be better balanced when they left the factory. This was finally accomplished after continuous effort extending over a period of about four years. Every part of the manufacturing process was refined further, until the unbalances existing in the individual lengths of cable were reduced to about one-quarter of what occurred when the development work started. These improvements not only have made it possible greatly to reduce the amount of special work during installation but also they have resulted in improved transmission efficiency and have enabled the number of pairs in a sheath of given size to be increased. Quadded

cables are now being used extensively by the Associated Companies and in the Long Lines plant and their use is increasing every year. The Boston-Washington cable contains seven quads of No. 10 gauge wires and eighteen quads of No. 13 gauge wires. In the interstices are placed six pairs of No. 13 and eighteen pairs of No. 16 gauge wires. The cable, therefore, provides 74 physical talking circuits and 25 phantom talking circuits, a total of 99. Advances in the art of loading have made it possible to load the phantom circuits as well as the side circuits in quadded cables.

ANTIMONY SHEATH

The sheaths of the cables used in the Bell System from an early date contained about three per cent. of tin alloyed with the lead. This alloy is considerably higher in breaking strength than unalloyed lead. The alloy, furthermore, proved beneficial, in underground cables, in reducing corrosion of the sheath from chemical causes. In aerial cables the alloy has been particularly important in practically overcoming the crystallizing and cracking of the sheath, which is liable to occur where unalloyed lead is used. About 1907, development work was undertaken looking to the discovery of a new alloy that should be at least as satisfactory as the lead-tin alloy and less expensive. Laboratory experiments and field trials were carried on over a period of four or five years covering a wide range of alloys. Consideration was given to the admixture, with lead, of antimony, tin, bismuth, nickel and copper in binary and ternary alloys of different proportions. Specimens were tested for tensile strength, and for ability to withstand bending, vibration and chemical corrosion under exposure to many reagents. Full size cables, with their sheaths made from different alloys, were repeatedly pulled in and out of ducts and their behavior, in comparison with sheaths of the then existing standard material, was noted. Other test cables were installed on bridges and elevated railway structures

in order that their ability to withstand continued vibration might be observed. The work resulted in the adoption of a new alloy consisting of about one per cent. of antimony alloyed with the lead. This was adopted for underground cables early in 1912, and for aerial cables about a year later. By means of this alloy more than five million dollars has already been saved in the first cost of cables in the Bell System.

CONCLUSION

One of the interesting points in connection with our cable development is that it has been closely connected with the constantly increasing knowledge of the theory of alternating current transmission. Not until the phenomena associated with the transmission of electrical waves over conductors were well understood, was the discovery and development of the loading principle rendered possible.

Many experiments had been conducted introducing inductance in telephone circuits but not enough was known to appreciate that the spacing of the coils in relation to the length of the electrical waves was the key to the solution. The repeater and the circuits in which it is used could not be made available until further advances in electrical knowledge had been made. The dependence of improvements in the electrical arts upon researches in the underlying fundamental theory is thus clearly indicated. Much important work in this field has been done by engineers of the General Staff.

Another point to be noted is the progress made in late years as the result of organized development and research. Our most important recent improvements cannot be credited to individual workers. Literally hundreds of engineers and scientists have been engaged on these problems, portions of the work being assigned to each. It has been a case of team work rather than of individual plays and it is by such methods that the advances which the future holds in store will be made.

Nature is reticent in revealing her secrets and organized effort is becoming more and more necessary to force her to disclose them.

F. L. RHODES.

Europe's Changing Attitude Toward Government Telephones

MOST telephone men are probably familiar with the fact that in the principal European countries the telephone services are wholly or largely owned and operated by the respective governments, and that up to the close of the World War there was a tendency in Europe toward extending public ownership of the telephone systems to include those still in the hands of private companies. It is probably not so well known, however, that a rather significant change in public and official sentiment regarding government ownership and operation of the telephone service has become manifest in various parts of Europe since the war.

THE EARLY TREND TOWARD GOVERNMENT OWNERSHIP

At the time when the telephone was introduced, the telegraph system was already a government monopoly in practically every European country, and the telegraph officials were prone to look upon the new method of communication as a potential competitor to be discouraged, rather than as a public service to be developed. Unwilling themselves to undertake the risks of launching a new enterprise, the government telegraph departments generally permitted the pioneer work of introducing the telephone to be done by private companies under more or less onerous restrictive licenses. When, however, the possibilities of the telephone began to be apparent, most of Continental governments proceeded to acquire the privately owned telephone systems, and the telephone was thereafter generally operated as an adjunct of the government telegraph department, and frequently in conjunction with the postal service. A desire to secure complete control of all means of communication as a measure of military preparedness was undoubtedly a

strong and in some cases the dominant reason for the establishment of government ownership of the telephone, as well as the telegraph, in most of the important countries of Continental Europe.

In England the military motive was not so prominent, and the movement from private to public ownership of the telephone system was slower than on the Continent. As early as 1880 the British courts held that a telephone system was a telegraph system within the meaning of the Acts of Parliament making the telegraph a monopoly of the Postmaster-General; and thereupon licenses were granted by the Post Office to a number of private telephone companies which ultimately consolidated into a single corporation. In 1896, however, the Post Office purchased the long distance lines, and thereafter the private company was restricted to the operation of local exchanges. In 1902 the Post Office also opened local exchanges in London, connecting with the company's system; and on December 31, 1911, upon the expiration of the company's license, the Post Office purchased its entire telephone properties. With the exception of three small municipal systems, all the telephones of Great Britain are now operated by the British Government through the Post Office.

To the influence of public ownership can undoubtedly be attributed at least a substantial part of the striking difference between telephone development in Europe where, generally speaking, government ownership prevails, and in the United States under private enterprise. Some detailed statistical comparisons in this regard were given in a recent article in the *BELL TELEPHONE QUARTERLY*.^{*} Of all the telephones in the world 64% are in the United States, while Europe with a population more than four times that of this country has only 25% of the world's telephones. There are, in fact, over 13 telephones for every 100 people in the United States,

^{*} World's Telephone Statistics, by S. L. Andrew, *Bell Telephone Quarterly*, October, 1922, page 45.

as compared with less than 1.5 for each 100 of population in Europe. It is significant that the highest number of telephones relative to population in Europe is found in countries in which the service has been developed principally by private enterprise. In Sweden, for example, where the service was largely developed by the Stockholm Telephone Company, whose properties were taken over by the Swedish Government only in 1918, there are about 7 telephones for every 100 people; and in Denmark, where all local telephone service is still under private ownership, there are 8 telephones per 100 of population.

TELEPHONE PROBLEMS AFTER THE WAR

The war left telephone systems the world over, whether publicly or privately owned, confronting problems of the greatest difficulty. The annual report of the directors of the American Telephone and Telegraph Company for 1919 sums up the situation in the United States:

"During the war the restriction on the use of capital and material, coupled with the unprecedented demand for service, compelled us in some places to exhaust our plant margins and left us at the beginning of 1919 with an actual shortage of plant to meet the then demands.

"We lost heavily during the war in men and women trained for our work and in young men in the minor supervisory positions. Handicapped by this lack of plant and of employees, especially supervisory officials, we entered upon the year of the greatest demands upon us."

Similar difficulties were encountered by the British telephone service. Sir Evelyn Murray, K. C. B., Secretary to the Post Office, testifying before a Select Committee of the House of Commons, appointed in 1921 to investigate the telephone service, declared that

"throughout the whole of the war period the normal and abnormal demands on plant continued, and gradually exhausted what spare plant we had got. Moreover, about 13,000 out of the 20,000 men in the engineering department joined the army, and consequently the maintenance of the plant had to be let down, and renewals had to be deferred except where they were absolutely essential. . . . At the beginning of 1919, as a result of

the war, the efficiency of the plant was very much below the proper standard, . . . and in about three-quarters of the towns of the country either the exchange accommodation, or the underground plant, or both, were exhausted and new subscribers could not be connected with the system until it had been extended."*

On the Continent these difficulties were, of course, greatly intensified. Not only were plant supplies extremely difficult to obtain, but the trained telephone personnel had, even in the neutral countries, been depleted by outside employment; and the telephone, as a business peculiarly dependent on personal service, was especially affected by the general lowering of morale which followed the war. Moreover, telephone financing presented an embarrassing problem to governments burdened with heavy war debts and inflated currencies. As late as the summer of 1921 a "revolt" of telephone users in Czecho-Slovakia was reported, owing to the passage of a law requiring every subscriber to the government telephones to purchase at least 6,000 kronen (then about \$78) worth of government bonds—the proceeds to be used in improving the telephone system—with loss of telephone service as the penalty for failure to buy the full quota of bonds.

THE DRIFT IN SENTIMENT AWAY FROM PUBLIC OWNERSHIP

Since the sale of the properties of the Stockholm Telephone Company to the Swedish Government in July, 1918, no important privately owned telephone system in Europe has passed into government ownership. Indeed, public opinion in several of the principal countries of Europe has, since the close of the war, shown a marked tendency to break away from the traditional European view which regarded the administration of the telephone service as an ordinary governmental function. The difficulties confronting telephone managements during the post-war period have given rise to a growing popular

* Report from the Select Committee on the Telephone Service, 1921, page 2.

belief that private enterprise is better fitted than governmental administration to meet the complex problems of telephone extension and operation. This reversal of previous trends is perhaps the most significant development of recent years in the field of European telephony.

In England the Post Office telephone service has been the subject of severe criticism, both in the press and at public meetings of telephone users, trade bodies, and civic associations, almost from the time when the Post Office first took over the properties of the private company. Since the war there have been repeated suggestions that the telephone system be sold to a corporation, in the interests of better service and extended development. In criticism of their telephone service Englishmen have made free use of the traditional British methods for airing grievances: letters have been written to the *Times*, and questions have been asked in the House of Commons. Answering such a question in Parliament at a time when post-war difficulties were perhaps at a maximum, Mr. Bonar Law declared that the government still refused to entertain the idea of retransferring the telephones to private enterprise. This called forth some sharp comment in the press, and one financial paper went so far as to canvass the possibilities of raising capital for the formation of a company to purchase the London telephone system outright; but the government has thus far adhered to its decision not to sell. A Parliamentary Select Committee was appointed, however, in 1921 to investigate the telephone administration; and although it reported that it was not within the terms of its reference to consider the restoration of the telephone service to private enterprise, "for which practically all United States authorities claim advantages,"* the Committee nevertheless raised the question whether in sparsely populated agricultural districts the Post Office should not delegate a certain amount of responsibility for telephone development to the subscribers themselves. The report

* Report from the Select Committee on the Telephone Service, 1922, page 9.

called attention to the existence of hundreds of small rural telephone companies in the United States and Canada, and expressed the opinion that a great deal might be done in the country districts of Great Britain to stimulate co-operative effort along similar lines.

RECENT FRENCH PROPOSALS

In France, although the telephone service has been a government monopoly since 1889, the movement for a return to private ownership has made greater progress than in England. In the fall of 1921, M. Deschamps, who had himself at one time been Minister of Posts, Telegraphs and Telephones, introduced in the French Parliament a bill, signed by 290 members of the Chamber of Deputies, instructing the Department of Posts, Telegraphs and Telephones to present within three months a plan for the restoration of the government telephone system to private ownership. M. Paul Laffont, the then Minister of Posts, Telegraphs and Telephones, thereupon offered a bill to remedy the defects of the existing system, while retaining the monopoly; and M. Deschamps, after appearing before the Parliamentary Committee on Public Works, withdrew his proposal. Complaints regarding the quality of the government telephone service continued to pour in, however, and in the spring of 1922 a bill for the improvement and extension of the telephone system was introduced in the Chamber of Deputies, and referred to its Committee on Public Works and Means of Communication. The committee made an examination of telephone conditions not only in France, but in several other countries as well, and in July, 1922, submitted to the Chamber of Deputies a report calling attention emphatically, though briefly, to the inferiority of the French telephone service when compared with the service in Denmark and Sweden and, especially, in the United States. This inferiority the Committee attributed primarily to inherent defects in the administrative organization of the service by the French Government, as contrasted

with the effective organization which obtains in the United States, where the report described the management of the telephone system as being in the hands of technically qualified specialists imbued with the commercial spirit, which results in constant search for improvements whereby telephone users may be given a more and more satisfactory service. For the purpose of improving the administrative organization of the telephone service in France, the committee recommended that the government be authorized to delegate the operation of local service to private companies, at least experimentally. Nevertheless, despite the report of its committee, the Chamber of Deputies, on December 23, 1922, defeated an amendment to the budget, proposed by Deputy Jean Lambert, authorizing the government to dispose of all or part of its telephone system to private companies. The matter, however, has probably not been permanently settled in France; and in view of popular dissatisfaction with the government telephone service, and of the pending plan for the transfer of the state railroads to private companies, further proposals for the restoration of the French telephones to private operation are likely to be brought forward at any time. Indeed, it is reported that the French Government has within the last few months entered into a contract whereby a private company is to receive an exclusive franchise for 20 years to operate coin-box telephones in booths throughout the country.

NEW POLICY IN ITALY

Although in England and France the proposal that the government telephone systems be sold to private companies has not yet progressed beyond the stage of popular and Parliamentary discussion, in Italy it has been made a definite part of the government's policy. From the very beginning of the Fascisti movement one of the cardinal planks in Signor Mussolini's platform has been the gradual abolition of government ownership

of business enterprises; and among the first official declarations of his government was a statement that the publicly owned utilities, including the telephones, would be turned over to private companies, in order to relieve the government from the deficits incurred in their operation.

A committee representing the Ministries of Posts, Telegraphs and Telephones, Public Works and the Treasury, has for some months been considering applications for telephone concessions. The terms on which such concessions will be granted are set forth in some detail in a statement made public a few weeks ago by the Minister of Posts, Telegraphs and Telephones. This statement declares that, on assuming office, the present government found many districts without telephone facilities, and that elsewhere the equipment was inadequate and the service unsatisfactory. This condition, the government concluded, could only be remedied by a return to private enterprise, since any other course would augment the existing deficits in the national budget. Accordingly the decree organizing the telephone service authorizes the government to transfer the operation of the telephones, and perhaps the ownership of certain systems, to private companies or individuals, under concessions with an indeterminate duration, but for not less than 25 years. Provision is made for the government to receive either cash or stock in payment for the telephone equipment sold, and an annual rent is to be paid by the operating company to the state equal to not less than 5% of the gross profits, plus a part of any net profits over and above 7%. The statement of the Minister of Posts, Telegraphs and Telephones indicates that the authorities have not yet decided whether to turn over the entire telephone service of the country to one concern, or to divide it among a number of local companies to be associated in a single system.

Banks and prominent industrial interests are, however, urging the early transfer of the telephone system, particularly in the industrial centers such as Milan,

Genoa and Turin, to private operation; and it is reported that definitive action may be expected as soon as some of the government's more pressing problems have been solved, and as soon as it has been decided whether provision should be made for the employment elsewhere of the surplus telephone personnel now on the government payroll.

Greece, like Italy, has apparently reached a definite decision to transfer her governmentally owned telephone system to private ownership, and the government has invited proposals from foreign companies for the modernization, extension and operation of the Greek telephone service, which has been a government monopoly for many years. Poland, too, has provided for a privately owned telephone system in her principal cities, to be operated by a company in which the Polish Government is to have only a minority interest. In Spain, where private telephone concessions in several cities have recently expired by limitation, the companies have continued to operate on sufferance without franchises. The government has apparently not yet adopted any definite policy; and despite reports that government ownership would be put into effect, the authorities have recently been negotiating for operation of the telephones under proposed new franchises to be granted to private concerns. Even the Russian Soviet Government is reported to have granted concessions to a private company for the operation of telephone systems in Moscow, Petrograd and other cities.

REASONS FOR THE CHANGE IN SENTIMENT

The reasons for this well defined reversal during the past few years of the trend toward government ownership of telephones, which was in evidence in Europe before the war, are not far to seek. Widespread dissatisfaction with the service rendered by the government owned telephone systems of Europe was manifest for many years prior to the war, and official and unofficial

investigations of telephone conditions were frequent. Even then European critics of the telephone service in their own countries were referring in highly complimentary terms to the telephone facilities furnished under private ownership in the United States. It was the difficulties resulting from the war, however, which brought matters to a head. Recurring deficits from the operation of the telephones, which before the war could be more or less easily made up out of general taxation, became a serious matter for States burdened by heavy war debts and inflated currencies. The financing of extensions of the telephone systems became a grave problem. Moreover, it is a peculiar weakness of government departments in all countries that they are not adaptable to new or emergency conditions. They inevitably tend to become static, while the telephone is a business which requires a dynamic administration. The extraordinary shortages of material and of trained personnel which followed the war, almost everywhere coincided with greatly increased demands for telephone facilities due to the accumulated shortage of new installations which was carried over from the war years. It required tremendous personal effort all along the line in every telephone organization to overcome these difficulties. Even under the stimulus of efficient corporate management it could only be done by months of untiring work, and by constant application of all the energy and initiative at the command of telephone executives. In cases in which telephone service had for years been administered under a more or less rigid governmental routine, necessarily tending to hamper the exercise of initiative and to discourage the ambitions of the personnel, it is not surprising that the extraordinary difficulties of the post-war period appeared well-nigh insurmountable. This more than any other single factor probably accounts for the growing sentiment in Europe in favor of private ownership and operation of telephone properties.

R. S. COE.

The Second National Radio Conference

THE Second National Radio Conference called by Mr. Hoover, met at the Department of Commerce in Washington, Tuesday, March 20, 1923. The members of the conference were as follows:

MAJ. GEN. GEORGE O. SQUIER, War Department,
COM. D. C. BINGHAM, U. S. N., Navy Department,
W. A. WHEELER, Department of Agriculture,
JOHN W. SUTHERIN, Post Office Department,
F. P. GUTHRIE, United States Shipping Board,
EDWIN H. ARMSTRONG, Columbia University, New York,
DR. ALFRED N. GOLDSMITH, Secretary, Institute of Radio Engineers,
PROF. L. A. HAZELTINE, Stevens Institute of Technology,
JOHN V. L. HOGAN, Consulting Radio Engineer, New York,
C. B. COOPER, National Radio Chamber of Commerce, N. Y.,
HIRAM PERCY MAXIM, President, American Radio Relay League,
PROF. C. M. JANSKY, University of Minnesota,
A. H. GRISWOLD, American Telephone and Telegraph Company,
LEO FITZPATRICK, Radio Editor, *Kansas City Star*,
D. B. CARSON, Department of Commerce, Bureau of Navigation,
W. D. TERRELL, Department of Commerce, Bureau of Navigation,
J. H. DELLINGER, Department of Commerce, Bureau of Standards,
L. E. WHITTEMORE, Department of Commerce, Bureau of Standards,
W. HEATH, Representative of the Treasury Department.

Mr. Hoover in an opening address stated in effect that due to the failure of Congress to pass the White Radio Bill, he had called this conference in order that he and the Department of Commerce might have the benefit of the advice of those qualified in the art and interested in the industry, to the end that he might formulate and put into effect such new rules and regulations as were consistent with the advancement in the art and as were possible under the existing laws.

The meetings on Tuesday and Wednesday were devoted largely to open hearings to which the general public was invited. Thursday, Friday and Saturday were devoted to executive sessions.

The keynote of the conference was broadcasting with the particular thought in mind that interference must be minimized. Considerable discussion was had with reference to the opening up of wave lengths from 600 to 1,600 meters and placing in this range some of the broadcasting services. The conference, however, agreed that it was not wise to go above 600 meters with broadcasting, since very few of the existing receiving sets will receive wave lengths longer than 600 meters and also, since it seemed undesirable to have other services interspersed between the various broadcasting services. It was agreed that it was desirable that all broadcasting be in the range under 600 meters, and if possible, that it be in a solid block of wave lengths.

In order to accomplish this, it was necessary to eliminate some amateur, commercial and government use of wave lengths below 600 meters. This was done by giving the amateurs the range below 222 meters down to 150 meters and by placing in the range above 600 meters the government and commercial services now in the range below 600 meters. In this manner wave lengths from 222 meters to 545 meters were provided solely for broadcasting with the important exception of the 300-meter international ship-telegraph wave length, on which traffic is to be minimized as much as possible.

The present 450-meter ship-telegraph wave length is not an international assignment and it was agreed that traffic on this wave length would be discontinued as rapidly as possible. For the present no traffic is to be handled on this wave length between the hours of 7 P.M. and 11 P.M., which is the most important broadcasting period.

In the range assigned to broadcasting, the higher power Class A broadcasting stations are to take the band from 288 to 545 meters, in which band there are fifty telephone broadcasting channels 10,000 cycles apart. The United States was divided into five zones and provision was made for ten of these Class A channels in each

zone. The ten channels within each zone are so assigned that they are separated by 50,000 cycles. The separation of channels between contiguous zones is 20,000 cycles, and as previously stated, all channels are at least 10,000 cycles apart and no wave length is repeated throughout the country. These Class A wave lengths have been tentatively assigned to the principal localities within each zone so that Class A stations located at these points will comprehensively cover the entire United States.

The Metropolitan area of New York will have four Class A wave lengths, Chicago will have three and San Francisco, two; all other localities will have one each and if more than one Class A station is erected at any of the points where only a single wave length is provided, the time must be divided as only one of them will be permitted to operate at one time. By this arrangement the man-made interference in the higher class broadcasting in the country should be largely eliminated, and theoretically, under proper operation, one will be able to select any one of the 50 Class A localities within his range and exclude all other stations. It was generally agreed that all Class A stations should adhere to certain standards of quality and should have a power not less than 500 watts input. No upper limit, however, was provided and it seems reasonable to assume that inasmuch as each Class A station will be able to operate without interference from other broadcasting stations, the power of such Class A stations should be considerably increased to overcome natural interference. This will be decidedly in the interests of the radio listener.

All stations under 500 watts are to be known as Class B stations and a block of wave lengths between 222 meters and 286 meters is provided for such stations. In this block there are about 35 channels 10,000 cycles apart. For the lower power Class B stations it will be possible to reuse many of the wave lengths a considerable number of times and it is understood that the Department of Commerce will lay out a proper staggering and zoning scheme

for the Class B broadcasting services similar to that established for the Class A broadcasting services.

The effect of the new broadcasting plan should be—

1. A great reduction in interference.
2. An extension of the desirable range of the listener.
3. The ability to select a much larger variety of programs.
4. To limit the promiscuous establishment of new broadcasting stations.
5. To discourage the continued operation of inferior existing stations.

On the whole, with the proposed plan in effect, renewed enthusiasm in radio broadcasting ought to result.

In the Report of the Conference, the way is left open to take care of small marine craft such as tugboats in harbors in the range under 130 meters. Also, provision is made for one two-way channel of ship-to-shore radio telephone communication in the range between 800 and 1,277 meters. While this reservation for ship-to-shore telephone communication may result in some interference from other marine services, the conference representatives having to do with these marine services indicated that they would do what they could in minimizing such interference.

It is an interesting fact that except for essential mobile services such as ships and aircraft, the conference made no provision for point-to-point radio telephone communication.

The Report of the Conference which includes the above plans, proposes a decided forward step in clarifying the radio situation, particularly with reference to broadcasting, and recommends that the Secretary of Commerce put the recommendations into effect without delay. Mr. Hoover indicated his desire to do everything possible to clear up the radio situation and stated that he would recommend supplementing, if necessary, existing legislation with an Executive Order.

A. H. GRISWOLD.

Abstracts of Recent Technical Papers from Bell System Sources

Extraordinary Diffraction of X-Rays,¹ by L. W. McKeehan. Crystals containing elements whose characteristic X-Ray spectra can be excited by the monochromatic incident X-rays used in the powder method of crystal analysis give diffraction effects not completely explained by the usual theories. The surplus diffraction spots are, however, explained, qualitatively at least, by assuming that the incident radiation contains regularly spaced trains of singularities (waves) each capable of initiating characteristic secondary X-rays, naturally always of greater wave-lengths than the corresponding primary X-rays, from the atoms of the crystal. It must, further, be assumed that the relations in time and phase between the primary and secondary waves are the same at all emitting centers. The angle of deviation of the diffracted rays of characteristic type is found to depend upon two wave-lengths instead of one and can assume values impossible to non-characteristic rays diffracted by the same crystal. The analysis is given for a simple type of crystal analogous to those with which the new effects were observed, and emphasis is laid upon the differences between what it is proposed to call "extraordinary diffraction" and the previously recognized, or ordinary, diffraction effects.

The Crystal Structure of Bismuth,² by L. W. McKeehan. The crystal structure of bismuth has been reported previously, but in view of the peculiar electromagnetic properties of this metal it seemed advisable to check the proposed arrangements by the powder method of X-ray crystal analysis. The detail of the method was new in employing relatively large crystals and comparing the frequency distribution of the spots on the photograph

¹Journal of the Optical Society of America, Vol. 6, pp. 989-997, December, 1923.

²Journal of the Franklin Institute, Vol. 195, pp. 59-66, January, 1923.

with the distribution to be expected with the proposed arrangement. This is convenient for complicated structures like that of bismuth, because the number of possible diffraction maxima within the range of the photographic film is so great that a finely powdered sample gives very little intensity in any one of them. It is concluded that the evidence is in favor of a structure based on two interpenetrating rhombohedral space lattices, the unit cell in each being a rhombohedron 6.546×10^{-8} cm. on each edge and with an acute face-angle equal to $57^{\circ}-16'$, the two lattices being separated along the trigonal axis, the principal body-diagonal of the rhombohedron, by 0.474 ± 0.003 of its length.

Specializing Transportation Equipment in Order to Adapt it Most Economically to Telephone Construction and Maintenance Work,³ by J. N. Kirk. This paper describes the application of motor vehicles and their associated apparatus to outside plant construction and maintenance work. The development and the stages of such equipment are portrayed beginning with the horse and buggy and progressing up to the modern heavy truck carrying specialized locker compartments, racks, and winding winches. The design of all transportation equipment has been carefully considered with a view to saving the time of construction gangs and increasing the safety of conditions under which they work. A curve is shown on the growth of the motor vehicle fleet in the Bell System from 1904 to the present time. This fleet now numbers over 8,000 vehicles.

Telephone Transmission Over Long Cable Circuits,⁴ by A. B. Clark. The application of telephone repeaters has made it possible to use small gauge cable circuits to handle long distance telephone service over distances up to and exceeding 1,000 miles.

Many of the circuits in these toll cables are so long electrically that a number of effects, which are com-

³Bell System Technical Journal—January, 1923.

⁴Journal of the A. I. E. E., January, 1923, and Bell System Technical Journal—January, 1923.

paratively unimportant in ordinary telephone circuits, become of large and sometimes controlling importance. For example, the time required for voice energy to traverse the circuits becomes very appreciable so that reflections of the energy may produce "echo" effects very similar to echoes of sound. The behavior of the circuits under transient impulses, even when two-way operation is not involved so that "echoes" are not experienced, is very important. In order to keep within proper limits of variation of efficiency with frequency over the telephone range special corrective measures are necessary. Owing to the small sizes of the conductors, the attenuations in the longer circuits are very large. Special methods are, therefore, required to maintain the necessary stability of the transmission, including automatic means for adjustment of the repeater gains to compensate for changes in the resistance of the conductors caused by temperature changes.

Theory and Design of Uniform and Composite Electric Wave-filters,⁵ by Otto J. Zobel. This paper presents general methods of wave filter design together with representative designs which have been developed in connection with the utilization of this device in the plant of the Bell System. The paper gives first a general theory of design by means of which may be explicitly determined the structure of a uniform type of wave filter having any preassigned transmitting and attenuating bands as well as desirable impedance and wide arbitrary constants. This theory is then applied to the design of a low-and-band-pass wave filter from which are derived design formulas for all the uniform wave filter structures in present use.

The subject of composite wave filters is also taken up, these being known as uniform wave filter networks obtained by combining sections of filters having equivalent characteristic impedances but different propagation constants. Among others, a superior advantage of the

⁵Bell System Technical Journal—January, 1923.

composite over the uniform wave filter is its greater flexibility of design as a result of which composite filters are often the only means of meeting severe design requirements.

Probability Curves Showing Poisson's Exponential Summation,⁶ by George A. Campbell. In many important practical operations the constant probability of an event happening in a single trial is extremely small but the number of trials is so large that the event may actually occur a sufficient number of times to become a matter of importance. This paper gives, in the form of tables and curves, a result of extensive computations of the probability that such an event will happen at least c times in a number of trials for which the average number of occurrences is a . The probability range is from .000001 to .999999 and all average extends from 0 to 200. The results as given in the curves and tables are used in certain probability problems arising in connection with the laying out of trunking facilities in telephone offices.

Bell System Sleet Storm Map,⁷ by J. N. Kirk. This paper describes sleet storm records which have been collected throughout the United States since 1911, and in so far as possible the collection of these data was made retroactive. From the data a map has been prepared in which the destructive effect of storms over a considerable number of years is indicated, the severity of the storms being measured directly in terms of destruction to telephone plant. Charts are given showing the load on the wire and pole plant due to wind and sleet alone and the two combined.

Measurements on the Gases Evolved from Glasses of Known Chemical Composition,⁸ by J. E. Harris and E. E. Schumacher. This paper has a very direct bearing upon the pumping or exhausting of the vacuum tubes used in telephone repeaters and similar thermionic tubes. The

⁶Bell System Technical Journal—January, 1923.

⁷Bell System Technical Journal—January, 1923.

⁸Journal of Industrial and Engineering Chemistry, February, 1923, and the Bell System Technical Journal, January, 1923.

telephone repeater bulb, as is well known, holds a vacuum of the order of 10^{-6} mm. of mercury. In order to produce this vacuum it is necessary during the manufacture of the tube to not only remove the air from the space within the bulb but also to allow very considerable amounts of various gases to diffuse out from within the glass of the bulb and the metal parts of the tube structure. The volume of gas which is frequently removed from the metal plates, for instance, may be roughly estimated as 100 times the volume of the plates themselves, the volume of the gas being measured at atmospheric pressure. To remove these gases from the bulb and metal parts, it is necessary to maintain during the pumping process a temperature which is far above the normal temperature and a fair degree of vacuum within the bulb for a period of time which varies from a few minutes to an hour or more depending upon the type of tube.

With a view to simplifying the pumping process, the authors have found that a glass relatively free from absorbed gases can be produced by using special precautions in manufacture. The authors have also measured and analyzed the gases evolved from glasses of various composition. Seven different samples representing four distinct types of glass have been experimented with. Six of these samples of glass have been carefully analyzed and definite relations found between the amounts and kinds of gases evolved and the chemical composition of the glasses.

The Transformation of Color Mixture Equations From One System to Another. II. Graphical Aids⁹. This paper is a continuation and amplification of a previous one by the same writer. The general problem considered is the correlation of all systems of color measurement. The only unique measurement of color is the physical measurement of the distribution of radiant intensity through the spectrum. Such measurements are, however, not easily interpreted in terms of color sensations, and the number

⁹Herbert E. Ives, Journal of the Franklin Institute, January, 1923, p. 23.

of measurements necessary is inconveniently large. Much simpler, theoretically, are the three element systems of measurement. These depend upon the experimental fact that all colors may be matched by mixtures of three, usually chosen as red, green, and blue. According to whether the unit of value is the amount of the color necessary when mixed with the other primaries to make white, or the amount which is of equal luminous value with the other primaries chosen, measurements of this sort may be expressed in either one of two rectangular coordinate systems. When the units are equal luminous values of the primaries, it has been customary to express the results in terms of the relative amounts, on a luminous scale, of white and a spectrum color which must be mixed to match the test color, together with a statement of the wave length of the spectrum color. In the first of this series of papers the analytical expressions are developed for transforming measurements made by any of these systems of color measurement into values on the other systems. In this second paper a number of graphical aids are described, leading to several charts by means of which the transformations in question are greatly facilitated.

Notes on Recent Occurrences

TRANSATLANTIC RADIO TELEPHONE EXPERIMENTS

NEW honors in the field of telephone research were achieved by Bell System engineers when, on the night of January 14, executives of the American Telephone and Telegraph Company talked from the United States to England by radio telephone.

Sitting in his office on the twenty-sixth floor of the Telephone and Telegraph Building, 195 Broadway, New York, H. B. Thayer, president of the company, spoke into a telephone words which were carried over cables and open telephone wires to Rocky Point, L. I., transmitted through the ether, and plainly and distinctly heard by a group of scientists and newspaper representatives assembled at New Southgate, a suburb of London.

The Rocky Point sending station is owned by the Radio Corporation of America. The radio apparatus and system used was made possible by cooperation between this company and the American Telephone and Telegraph Company and is the result of research and experimental work in the laboratories of American Telephone and Telegraph Company and the laboratories of the Radio Corporation of America and its associated companies.

Transatlantic radio telephony is not new. In 1915 Bell System engineers succeeded in sending the human voice by radio telephone from Arlington, Va., to Paris. The experiment of January 14, however, differed from that of eight years before in that it was carried out along lines definitely prearranged, the program extending over a period of exactly two hours. Whereas, in the experiments of 1915, a few words and sentences were intelligible, in the later test thousands of words were transmitted and received in England so clearly and distinctly

that the intonations of the speakers were recognized by their friends and acquaintances.

In addition to Mr. Thayer, Vice Presidents John J. Carty and Walter S. Gifford of the American Telephone and Telegraph Company also sent messages to England, as did several engineers of the Development and Research Department staff. The arrangements for the experiment in England were in charge of Frank Gill, European Chief Engineer of the International Western Electric Company.

One-way transmission only was possible, because of the lack of suitable sending apparatus in England. Confirmation of the receipt of the messages was received by cable, the first cablegram being received eleven minutes after Mr. Thayer began speaking.

The transmission of actual messages was preceded by several weeks of experimentation in which isolated words were used for test purposes. In the course of these preliminary tests a mass of data in regard to the transmission characteristics of the ether was obtained. It is believed that these records will be of considerable value in the research work being carried on by Bell System engineers.

JOINT MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS IN NEW YORK AND CHICAGO

ONE of the attractions on the program of the mid-winter convention of the American Institute of Electrical Engineers was a joint meeting between 1000 members assembled in New York and 500 members assembled in Chicago. The meeting was held on the evening of February 14th, President F. B. Jewett presiding from New York. The two assemblies were united as though in a single auditorium through the agency of the Western Electric Company's public address system associated with the long distance telephone lines of the American Telephone and Telegraph Company, in such manner as

to give two-way loud-speaker operation. By means of this installation papers which were read in New York were heard simultaneously by the audience in Chicago and papers read in Chicago were also heard at New York. After the papers were read they were discussed before the two audiences by Mr. J. J. Carty, Vice President of the American Telephone and Telegraph Company and Mr. E. B. Craft, Chief Engineer of the Western Electric Company, speaking in New York and Mr. B. E. Sunny, Chairman of the Board of Directors of the Illinois Bell Telephone Company, speaking in Chicago.

The technical aspects of the loud speaker installation, except for the two-way transmission feature, were similar to those employed at the ceremony attending the burial of the Unknown Soldier when audiences in Washington, New York and San Francisco heard the exercises. These technical aspects were discussed in two papers, the first by I. W. Green of the American Telephone and Telegraph Company and J. P. Maxfield of the Western Electric Company and the second by W. H. Martin and A. B. Clark of the American Telephone and Telegraph Company.

At each auditorium the only apparatus visible was a small but very sensitive transmitter which stood on the speaker's desk and a group of small horns suspended above from which the amplified voices were emitted. In addition to the visible apparatus, powerful vacuum tube amplifiers were used to magnify the speaker's words. Sets of these amplifiers as well as the transmitters and horns were located at both New York and Chicago. The long distance wire telephone circuit joining the two audiences carried special equipment so as to deliver the speakers' voices at either end with a minimum of distortion.

A special telephone circuit also carried the speakers' voices to the radio station WEAf in New York from which they were broadcast to many thousands of listeners who were not in attendance at either auditorium.

SECOND TRANSCONTINENTAL ROUTE PLANNED

PLANS are nearing completion for work which will make available a second transcontinental route. The construction work which it is expected to complete this year involves pole line work, wire and equipment installations from Denver via El Paso to Los Angeles.

Transcontinental telephone service was first made available to the public in January, 1915. Prior to that time, two routes, both carrying long haul circuits, had been extended as far West as Denver. The extension of this service to the Pacific Coast involved the construction of many miles of new pole line, the stringing of four 165 (No. 8 B.W.G.) wires between Denver and San Francisco, extensive rearrangements of the existing circuits east of Denver, and the installation of telephone repeaters and associated equipment at suitable points between New York and San Francisco. High quality telephone service has been furnished over these circuits since their completion, various improvements having been made from time to time as the art advanced.

The four 165 wires when originally provided west of Denver made available more telephone facilities than were regularly required at that time for through traffic, and part of the circuits were used for business to intermediate points between Denver and San Francisco. All of these facilities are now required for through business and some 104 (No. 12 N.B.S.) wires have been provided to serve the intermediate points.

While the provision of additional facilities to handle the shorter haul traffic west of Denver has made it possible to care for a greatly increased volume of business, the demand for through telephone service continues to increase and additional facilities must now be provided.

After carefully considering all of the factors involved, it has been decided that the service as a whole can be best safeguarded by providing the additional facilities

now required on a second route, and arrangements are under way to make four 165 gauge wires available from Denver to Los Angeles via El Paso. The carrying out of this plan will make available two separate routes carrying long haul circuits from the Pacific Coast to points east of Denver, two such routes having been available east of Denver since transcontinental service was started. As the new route is largely through a section of country where few severe storms are experienced, a high degree of protection to this very important service will be furnished. In addition, the circuits to be provided on the new route will more satisfactorily handle the rapidly increasing requirements for through service between Los Angeles and other southern California points and the East.

The provision of facilities along this route is in line with the plans for permanent extensions of the trunk lines for nation-wide service which contemplated the provision of at least three main transcontinental routes with suitable North and South tie lines. One of the two new routes planned will extend from New Orleans and Dallas via El Paso to Los Angeles, and the other from Minneapolis via Fargo and Billings to Seattle. The work being undertaken this year fits in with the plans for the Southern Route.

THE ANNUAL MEETING

THE annual meeting of the stockholders of the American Telephone and Telegraph Company was held at the headquarters building at 195 Broadway, New York, on March 27th, and the directors were re-elected by a vote of 4,473,838 shares, there being no dissenting vote.

The stockholders' representation was very satisfactory, there being over 150 shareholders present in person and 156,922 shareholders represented by proxies. The transactions of the past year were approved.

Preceding the annual meeting, a special meeting was held at which it was voted to increase the authorized capital stock to 10,000,000 shares or \$1,000,000,000, as recommended in the annual report to meet future requirements of the business. Mr. Thayer stated that no immediate offering of stock was contemplated.

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Bell System house flag as flown during the conference of Presidents
at Yama Farms

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The Early Corporate Development of the Telephone

The technical growth of the telephone has been made a matter of history, but the corporate growth of the American Telephone & Telegraph Company and its predecessors is not so well known. Now that the telephone is approaching its fiftieth year and while there are people in the business who were in it from the very early days, it seems well to review the steps of its progress.

THE qualities which characterize the Bell System of the present day have all grown from right beginnings made by the small group of men who from 1875 to 1885 controlled the telephone industry and started it fairly on its way toward universal service. Bell, Sanders, Hubbard, Watson, Forbes and Vail seem, each in his own line, instinctively to have known the principles, the methods and the practice which in less than fifty years would make of the telephone a well centralized but democratic federation of companies, a sound financial institution, an efficient and progressive engineering utility, and therefore the habitual reliance of the civilized world.

While Alexander Graham Bell himself never carried the invention of the telephone beyond its elementary stage, he foresaw in very specific detail the possibilities

of universal communication to which, with the addition of the exchange and long lines systems, his invention would ultimately be developed. In an address which served as a prospectus for a group of London capitalists, dated March 25, 1878, Mr. Bell wrote (with slight omissions),—

“It is conceivable that cables of telephone wires could be laid underground, or suspended overhead, communicating by branch wires with private dwellings, country houses, shops, manufacturing, &c., &c., uniting them through the main cable with a central office where the wire could be connected as desired, establishing direct communication between any two places in the city. Such a plan as this will, I firmly believe, be the outcome of the introduction of the telephone to the public. Not only so, but I believe in the future wires will unite the head offices of the Telephone Company in different cities, and a man in one part of the country may communicate by word of mouth with another in a different place. Believing as I do that such a scheme will be the ultimate result of the telephone to the public, I will impress upon you all the advisability of keeping this end in view, that all arrangements of the telephone may be eventually realized in this grand system.”

THE “BELL PATENT ASSOCIATION”

The first germ of a corporate form for the business development of the telephone was a verbal offer made by Thomas Sanders of Haverhill, Massachusetts, to Alexander Graham Bell in the fall of 1874 to supply him with money for his experimenting in return for a share in whatever patent rights might come from the work. A short time after this arrangement with Mr. Sanders, Gardiner G. Hubbard of Cambridge made Bell a similar offer. These informal offers and acceptances were later embodied in a written agreement, dated February 27, 1875.

This agreement provided that Mr. Sanders and Mr. Hubbard should each furnish one-half of the money necessary for Bell to perfect his inventions and to secure and maintain patents for them; and that the three should together own the patents. This personal association was not formal enough to have a name. To distinguish

it from other subsequent organizations it will here be called the "Bell Patent Association."

A week after this agreement of the "Bell Patent Association" was signed, on March 6, 1875, application was filed in the United States Patent Office at Washington for Patent No. 161,739, Improvement in Transmitters and Receivers for Electric Telegraphs. This patent was issued to Bell one month later, on April 6, 1875. It was the first of the tangible assets of the "Bell Patent Association." It did not, however, ever bring any financial income.

On June 2, 1875, while Bell was working with his assistant, Thomas A. Watson, to improve his multiple harmonic telegraph, he made the discovery which assured him that his theory about the electric transmission of speech was correct, and which made clear to him how to make an instrument that would produce the necessary undulatory current. Now at last he had something in the line of speech transmission that he could patent. Winning at once the approval of Mr. Hubbard and Mr. Sanders, Bell in large measure discontinued his work on the multiple telegraph and devoted his energies to developing the invention of the telephone.

THE FOUR FUNDAMENTAL PATENTS

In September, 1875, at his father's home near Brantford, Ontario, he began writing the specifications for the first telephone patent. In order to avoid conflict between American and British patent rights, he wished to delay the filing of the application at the United States Patent Office at Washington. So it was not filed until February 14, 1876. Credit is due to Mr. Hubbard that the application was not delayed even longer. The patent was allowed on March 3, 1876, Bell's birthday, and was issued to him on March 7, 1876, as Patent No. 174,465, Improvement in Telegraphy. It was the corner-stone of the Bell System of intercommunication.

The written agreement of the "Bell Patent Associa-

tion" did not speak of the telephone nor refer to it in a distinctive way. It stated the basis of the agreement to be that "the said Bell has invented certain new and useful methods and apparatus for telegraphing." Nor was this an instance of the interchangeable use of the two words, telegraph and telephone, common at the time, such as that in the title of the first telephone patent itself. It was either an inadvertent or a deliberate discrimination in favor of the telegraph. Mr. Sanders and Mr. Hubbard had both formerly believed that the multiple telegraph was the invention that would prove to be the profitable one, and at one time Mr. Hubbard had told Bell that their financial support was conditioned on his devoting his attention to that line of experiment.

This preference for the telegraphic inventions before long brought up a practical question of real importance, even affecting the ownership of the telephone. Dr. Bell has told about it.

"My understanding always was that the speaking telephone was included in the inventions that belonged to the Messrs. Hubbard and Sanders from the autumn of 1874, but I found at a later period that they had not had this idea, which might account for the little encouragement I received to spend time on experiments relating to it. Even as late as 1876, when the telephone was an assured success, Mr. Hubbard generously offered to relinquish to me all right and title to that invention, as he was inclined to think it was outside our original understanding."

It was not, however, outside of Bell's original intention, and after consulting with Anthony Pollock, their attorney, Bell took the position that the telephone was to be considered as included in the agreement. So this agreement of the "Bell Patent Association" by Bell's interpretation of it became the first legal instrument of corporate telephone ownership and organization.

The experimenting of the winter of 1875-1876 culminated in another patent, No. 178,399, Telephonic Telegraph Receivers. Application was filed for this patent on April 8, 1876, and it was issued to Bell on June 6, 1876. There were now three patents to the credit of Bell and of

the support he had received from Sanders and Hubbard. Of the first of these there could be no question of its being included in the agreement of the "Bell Patent Association." Of the other two there might be reasonable question. Therefore on September 15, 1876, Bell made an assignment of these two telephone patents to the three individuals who constituted the "Bell Patent Association,"—himself, Sanders and Hubbard. This settled for all time any possible question as to whether the telephone patents were or were not covered by the agreement of February 27, 1875. Incontrovertibly this assignment constituted the three men the first telephone organization.

To the three patents within a few months was added a fourth. On January 15, 1877, application was filed, and on January 30, 1877, letters patent were issued to Bell for Patent No. 186,787, Improvement in Electric Telegraphy. These four patents were the foundation of all the early telephone organizations of the Bell System.

THE TRUSTEESHIP OF GARDINER G. HUBBARD

The agreement of the "Bell Patent Association" had also specifically provided that if the expected inventions proved to be of value, a company should be organized to manage and control the patents; and that each of the three should own one-third of the stock of that company. By the summer of 1877 it was recognized that the condition provided for in the agreement had developed. Moreover, Mr. Bell was soon to marry Mr. Hubbard's daughter, and they were going to Europe for their wedding trip, to be gone for an extended period. Mr. Bell was to see what he could do to introduce the telephone into England. So it was advisable that the business affairs of the telephone should be put on a more definite and formal basis. Accordingly, steps were taken to organize a company. This was done by the appointment of Gardiner G. Hubbard as Trustee.

Anticipating such an outcome, and recognizing that

it would be wise definitely "to associate with them a practical mechanic of sufficient skill and ability, under Mr. Bell, to make these inventions pecuniarily successful," the three members of the "Bell Patent Association" had in the previous autumn made a contract with Thomas A. Watson, Bell's assistant. It was dated September 1, 1876. It provided that Watson should give at first half his time and later all his time to working on the patents. This was the beginning of the Bell System's research laboratories. In return Mr. Watson was to receive \$3.00 a day as wages, and a one-tenth interest in all the patents when the joint stock company was organized. This provision was now carried out.

Mr. Watson's distinctive contribution was along the line of the developing of the invention. He had little to do with the organizing of the business. From the time of Bell's sailing for Europe in July, 1877, until his own resignation and departure for Europe in June, 1881, he carried the burden of the necessary research work and superintended the making of the telephone instruments. Though he had had no scientific education, and though indeed of technical training for that work there was at that time none to be had anywhere, he had to solve or try to solve all the baffling technical problems that arose in telephone construction and operation. Taking up the work of Alexander Graham Bell, his was a large share in the making of Bell's invention a practical thing with commercial possibilities, and in those four over-worked years started the remarkable record of Bell System engineers in the solving of telephone problems and the advancing of the art of telephony.

The title of the declaration by which Mr. Hubbard undertook the responsibility of the business affairs of the telephone was the Bell Telephone Company, Gardiner G. Hubbard, Trustee. It was dated July 9, 1877. At the same time, the members of the "Bell Patent Association" made an assignment of all their rights under the four patents to the Trustee. This brought what has here been

called the "Bell Patent Association" to an end and vested all the rights and powers of the three men in Mr. Hubbard's Trusteeship.

THE LEASING OF TELEPHONES

The legacy of the Trusteeship to the Bell System was the leasing and licensing system. This led directly to the sale of service only, the fundamental principle of the business policy of the Bell System. Mr. Hubbard got the idea of leasing telephones instead of selling them from the practise of the Gordon-McKay Shoe Machinery Company, of which he was attorney. This company leased its shoe-sewing machines to the shoemakers, retaining the title to the machines and receiving a royalty for every pair of shoes sewed with the machines. Mr. Hubbard had the business control of the telephone in his own hands and adopted this method of distribution. The Declaration of Trust in its plan of organization provided for it and not for the sale of telephones, as follows:

"The business of manufacturing telephones and licensing parties to use the same for a royalty, shall be carried on and managed by the Trustee, under the name of the Bell Telephone Company, under and in accordance with such general directions, rules and regulations as may be made for that purpose by the Board of Managers."

Against strong pressure from most of his associates, and in spite of sore need for money at a time when sales would undoubtedly have brought in a greater income than the leases, Mr. Hubbard firmly held to the leasing principle as the wisest and best for the development of the telephone business. Certainly the unity and the nation-wide efficiency of the Bell System would have been impossible if he had yielded and tried to build the business up on a sale basis. To some of those concerned it seemed absurdly impractical, but it resulted ultimately in the munificent endowment of the Bell System.

The Declaration of Trust also provided for the division of the rights into 5,000 equal shares. The contract with Mr. Watson required that he should receive a one-

tenth right. Mr. Bell married Mr. Hubbard's daughter on July 11, 1877, and at that time made over to his bride practically all his financial interest in the telephone patents with her father as trustee for her. Mr. Hubbard also wished to bring his wife and his brother into the telephone ownership to a moderate degree. Accordingly on August 1, 1877, the telephone rights were converted from the ownership by the three men into the form of 5,000 shares of stock, the shares were apportioned, and certificates were issued by Gardiner G. Hubbard, Trustee, as follows:

	Shares		Shares
Alexander Graham Bell	10	Thomas Sanders	1497
Mabel Gardiner Bell	1497	Thomas A. Watson	499
Gardiner G. Hubbard	1387	Charles Eustis Hubbard	10
Gertrude McC. Hubbard	100		
		Total	5000

But money was very scarce. Mr. Sanders personally was still supplying most of what was needed. He was gallantly staking his entire fortune and credit to see the telephone through to success. Indeed he put in \$110,000 before he got a dollar back. Now again, when relief came to the finances of the telephone, it came through Mr. Sanders. He interested a group of Massachusetts and Rhode Island men. They agreed to put money into the telephone, but they wished to confine their interest and their responsibility to the development of the telephone within the territory of New England; and naturally, while willing to cooperate with the Trusteeship, they wished to control the telephone business within that territory.

THE FIRST NEW ENGLAND COMPANY

Accordingly the New England Telephone Company was formed. While there was no direct connection between this Company and the present New England Telephone & Telegraph Company, yet it is clear that the old New England Company pointed the way to the regional organization and federated relationships of the

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Associated Companies in the Bell System. The subscribers to the Articles of Association were:

Gardiner G. Hubbard	C. S. Bradley	Edward Sherwin
Thomas Sanders	G. L. Bradley	Joseph H. Goodspeed
Thomas A. Watson	Alexander Cochrane	W. G. Saltonstall
Chas. Eustis Hubbard	Rowland Hazard	G. Z. Silsbee

The office of the corporation was to be in Boston, and the capitalization \$200,000,—2,000 shares of \$100 each. The Certificate of Incorporation was dated February 12, 1878. The officers chosen were:

President, Gardiner G. Hubbard	Clerk, Chas. Eustis Hubbard
Treasurer, Thomas Sanders	General Agent, G. L. Bradley

The Articles committed the Company to Mr. Hubbard's policy of leasing and not selling telephones. They simply declared the intention to constitute a corporation "for the purpose of carrying on the business of manufacturing and renting telephones and constructing lines of telegraph therefor, in the New England States." On February 2, 1878, before the Certificate of Incorporation was filed, Gardiner G. Hubbard as Trustee made an assignment to the New England Telephone Company, of all rights under the four patents for the territory of the New England States. He did this by an agreement to license in consideration of the payment of \$1.00 and 1,000 shares, one-half of the stock, of the New England Telephone Company, to be issued: to Gardiner G. Hubbard, 600 shares; to Thomas Sanders, 300 shares; to Thomas A. Watson, 100 shares,—to each as trustee for the Bell Telephone Company. The agreement required that the New England Telephone Company buy its telephone instruments exclusively from the Bell Telephone Company at the price of \$3.00 for telephones and \$10.00 for magnetic calls, and specifically forbade the New England Company from selling the instruments, permitting them only to lease them to their subscribers.

The agreement further provided for cooperation between the Bell Telephone Company and the New England Company in conducting the telephone business within

and outside of the New England States, and in patent litigation. Finally, there was a specific provision in the agreement looking forward directly to the creation of the long lines:

"And insomuch as said parties and their successors and assigns may have a common interest in the working of continuous and connecting lines extending outside of New England, the said parties agree that they will endeavor to cooperate in the establishing of connecting lines and in the joint working of the same, and the division of the expense and the profits thereof pro rata upon some equally fair and equitable basis."

It is interesting that the coordination of subscribers' lines began, with the opening of the first commercial telephone exchange at New Haven on January 28, 1878, only five days before this agreement for the coordination of exchanges by a long lines system was signed.

THE BELL TELEPHONE COMPANY

The success of the New England Telephone Company in its territory suggested the advantage of a similar organization for the telephone business in the rest of the country. Money was needed; money could be secured from Mr. Sanders' friends on condition of such reorganization. Probably Mr. Vail, who accepted the position of General Manager in a letter dated May 22, 1878, also advised it as wise from the business point of view. Accordingly the Bell Telephone Company was formed.

This was not an incorporation of the Trusteeship, but an entirely new and different organization. The men who signed the Agreement of Association on June 29, 1878, to form the new Company were:

Gardiner G. Hubbard	Chas. Eustis Hubbard	Thomas B. Bailey
Thomas Sanders	Thomas A. Watson	James Sturgis
Alex. Graham Bell	A. O. Morgan	Joseph H. Goodspeed
(by Atty. G. G. H.) George L. Bradley		

The officers elected were:

President, Gardiner G. Hubbard	Clerk, Chas. Eustis Hubbard
Treasurer, Thomas Sanders	Gen. Mgr., Theodore N. Vail

The office was located in Boston, and the capitalization

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was \$450,000, 4,500 shares of \$100 par each. The Certificate of Incorporation was filed on July 30, 1878.

While there was actually no divergence from Mr. Hubbard's business policy of only leasing telephones, the new Company took to itself the right to sell the instruments by the following clause in the Articles of Association:

"The purpose for which the Corporation is constituted is to manufacture and sell telephones and their appurtenances and to construct, maintain and operate telephone lines and rent telephones throughout the United States outside of the New England States."

After this one glance in the tempting direction of sales, however, the policy of only leasing was maintained and unhesitatingly continued thenceforth.

In effecting the transfer of the control of the telephone to the new company, on July 20, 1878, Gardiner G. Hubbard as Trustee made an assignment to the Bell Telephone Company of "all the patents, patent rights and interest in any and all contracts relating to any patents or future inventions owned or held by him as Trustee," in return for 3,000 shares of the capital stock of the new Company; and also sold to the new Company all other property of every kind and description for \$42,500.

The actual control and real direction of the telephone industry therewith passed into the hands of an Executive Committee of the Bell Telephone Company, consisting of Gardiner G. Hubbard, Thomas Sanders and George L. Bradley, for whose authority the Directors provided by the following resolution:

"That the Executive Committee shall, until further orders, have all such powers as may be necessary for the management of the Company."

About the same time the differentiation of the two Companies was emphasized by a change in the officers of the New England Telephone Company. Mr. Hubbard and Mr. Sanders resigned as President and Treasurer on July 27, 1878, and their places were filled as follows:

President, Thomas Sanders Treasurer, George L. Bradley

Thus came to an end the Bell Telephone Company, Gardiner G. Hubbard, Trustee. Mr. Hubbard's exclusive control of the business affairs of the telephone had rendered its great service. It was with the endowment of the right business policy that the telephone went on to its next step toward the federated system of the American Telephone and Telegraph Company and its Associated Companies of the present.

UNITING TELEPHONE INTERESTS

On December 31, 1878, a new name appeared in telephone affairs. William H. Forbes was on that day elected a Director of the Bell Telephone Company. The telephone was now well launched into the period of patent litigation. Its prosperity had suffered from the superiority of the Edison transmitter, but now the Blake transmitter was brought to the Company by its inventor, and the advantage in the competition for the control of telephone service was restored to the Bell interests. Francis Blake, Jr., also was elected to the Board of Directors at the same meeting as Mr. Forbes. Within a month Mr. Sanders resigned as Treasurer of the Bell Telephone Company and George L. Bradley was elected to succeed him.

The opportunity which lay in the situation as a whole called for the strongest and most able business ability in the community. This was secured in the person of Mr. Forbes and the interests he represented. In effect this amounted to his taking over control of the telephone, for at a meeting of the stockholders on January 23, 1879, a by-law was passed providing that—

"The holders of one-third of the stock for which money has been paid and subscribed shall, for the space of two years, have an equal right and power with the holders of the two-thirds reserved to the patentees; and any holders of such originally subscribed stock shall cast two votes at each meeting upon each of such shares, and the holders of the stock originally issued to the patentees shall cast one vote on each of such shares during said two years."

The Early Corporate Development of the Telephone

This unquestionably placed the control of the Company's affairs in the hands of Mr. Forbes and those who were supplying the new money.

THE NATIONAL BELL TELEPHONE COMPANY

Mr. Forbes immediately, at a meeting of the Directors on January 29, 1879, took steps toward uniting all the Bell interests in one Company, the National Bell Telephone Company. The Articles of Association were signed on February 17, 1879, by the following men:

Gardiner G. Hubbard	Thomas B. Bailey	G. Z. Silsbee
Francis Blake, Jr.	R. W. Devonshire	Alex. Cochrane
Thomas Sanders	William H. Forbes	J. Cheever Fuller
George L. Bradley	Charles S. Bradley	C. E. Hubbard
Richard S. Fay	Alexander Graham Bell	

The purpose was stated in the Articles of Association as follows:

"To manufacture, sell and rent telephones and their appurtenances, and to build, maintain and operate lines for the transmission of messages by electricity or otherwise."

The office was to be located in Boston, and the capitalization was to be \$850,000, 8,500 shares of \$100 par each. The following officers were elected:

President, William H. Forbes	Treasurer, George L. Bradley
Clerk, Chas. Eustis Hubbard	Gen. Mgr., Theodore N. Vail
Electrician, Alexander Graham Bell	

The Executive Committee consisted of the President of the new National Bell Telephone Company, the Presidents of the two constituent Companies, and two of the new men:—William H. Forbes, Gardiner G. Hubbard, Thomas Sanders, Richard S. Fay, and Francis Blake, Jr. The Certificate of Incorporation was filed on March 13, 1879.

Of the \$850,000 of the stock of the new Company, \$200,000 was paid to the New England Telephone Company to distribute to its shareholders share for share; \$450,000 was paid to the Bell Telephone Company to distribute to its shareholders share for share; \$75,000 was

assigned to the money-paid or money-subscribed stockholders of the Bell Telephone Company on the 2 votes to a share basis; and \$125,000 was held as Treasury stock.

On March 20, 1879, both the New England Telephone Company and the Bell Telephone Company made assignments of their rights under two of the Bell patents, Nos. 161,739 and 178,399, to the National Bell Telephone Company; but they specifically excepted from their assignments the two distinctively telephone patents, Nos. 174,465 and 186,787. The National Bell Telephone Company never acquired title to these two patents during the life of the corporation.

Thus were the two former Companies consolidated. Thus was the development of the telephone and its introduction throughout the country unified by the organization of the National Bell Telephone Company under William H. Forbes. The name was an appropriate one. It was at this time that the Telephone entered into its truly national career, and its industrial development was dominated and chiefly directed by two men. William H. Forbes represented the East,—the East of the East,—with its conservative stability and its regard for tradition and social and financial standing. The telephone had scored as something to be permanently reckoned with when it secured a Forbes of Boston as its President. Theodore N. Vail represented the West with its direct freedom and disregard for anything but inherent merit. Although Vail was born in the East, the West had breathed the breath of its life into him and made him her own. Both individually and both in cooperation were essential at this time to the development of the telephone into a truly national utility and institution.

The National Bell Telephone Company had unified the development of the telephone, but it concerned affairs only inside the household, so to speak. It brought the family in under one roof, but the roof was not large enough to permit of very much increase in the size of the family. The pressure of affairs outside the Bell Telephone

household was within a year to render the National Bell Telephone Company quite inadequate to cope with the situation as a whole.

COORDINATION OF LOCAL COMPANIES

In the spread of the telephone over the country the method of local organization had usually been by means of local corporations which leased their instruments from the parent company. But if the telephone service was to be unified, which was becoming more and more evidently essential, the mere leasing of instruments would not be sufficient for a real coordination of the local interests with other local companies and with the parent company, even though this was before the days of the long lines connecting the various local city exchanges.

Further, there were rival telephone companies springing up to prey on the opportunity. To keep the local telephone companies from falling into the hands of these rival corporations by a transfer of a majority of their stock, it was not enough for the National Bell Telephone Company to lease the instruments. It must license the local companies exclusively. More than that, it must gain control of those companies by purchasing a sufficient proportion of their stock. This necessitated the command of a large amount of capital, far more than enough for the parent company to conduct its own regular business. The \$850,000 which in March, 1879, had been deemed ample, by March, 1880, had proved to be utterly inadequate.

In this situation the most serious competitor was the powerful Western Union Telegraph Company. During the early summer of 1879 the Western Union made it a matter of policy to buy up controlling interests in the companies organized under Bell licenses. The fight with the Western Union and the enormous increase of business which came with the settlement of that fight on November 10, 1879, on the basis of all telephone business going to the National Bell Telephone Company and all telegraph

business to the Western Union Telegraph Company, constituted the most important single element that made it necessary to reorganize the telephone business.

In order to permit this reorganization on an adequate scale and to permit the corporation to hold stock in other corporations, the Massachusetts Legislature passed a special act giving authority for the purpose, and it was signed by Governor John D. Long on March 19, 1880. The purpose as stated in this Act was for the

“manufacturing, owning, selling, using and licensing others to use electric speaking telephones and other apparatus and appliances pertaining to the transmission of intelligence by electricity, and for that purpose constructing and maintaining by itself and its licensees public and private lines and district exchanges.”

The capitalization was limited to \$10,000,000, and the permission to hold stock in other corporations was conditioned as follows:

“Said corporation may become a stockholder in or become interested with other corporations hereafter organized for like purposes, or already established for the transaction of telephone business under its patents and no others: Provided, that said corporation shall not become a stockholder in any other corporation doing business in this state to an amount exceeding 30% of the capital stock of said last named corporation.”

THE AMERICAN BELL TELEPHONE COMPANY

In accordance with this Act of Legislature, The American Bell Telephone Company was formed on March 20, 1880, by an Agreement of Association signed by the following men:

William H. Forbes	Charles Emerson	R. W. Devonshire
G. Z. Silsbee	George L. Bradley	Thomas B. Bailey
Francis Blake	Chas. Eustis Hubbard	C. M. Whitcomb
Richard S. Fay	W. G. Saltonstall	

The officers chosen were as follows:

President, William H. Forbes	Treasurer, W. R. Driver
Clerk, Chas. Eustis Hubbard	Gen. Mgr., Theodore N. Vail
Engineer, Joseph P. Davis	Supt. of Agencies, O. E. Madden
Consulting Engineers: Alexander Graham Bell and Francis Blake	
General Inspector, Thomas A. Watson	

The Early Corporate Development of the Telephone

The capitalization was fixed at \$7,350,000, 73,500 shares of \$100 par each, and the office was to be in Boston. The Certificate of Incorporation was filed on April 17, 1880.

The purchase by the American Bell Telephone Company of the stock of the National Bell Telephone Company was duly effected by payment of 6 shares of the new stock for 1 share of the old. This took up \$6,500,000 of the American Bell stock. The balance of \$850,000 was offered to the stockholders of the National Bell Telephone Company at par.

In order beyond any legal question to put into the hands of the new corporation all patent rights belonging to the Bell interests, assignments were made and licenses issued to the American Bell Telephone Company by all parties having any shadow of right or of ownership. Four of these were made in May and June, 1880; two more about a year later, in 1881; and even in 1885 confirmatory assignments were made to the American Bell Telephone Company by Alexander Graham Bell, and by Gardiner G. Hubbard, Trustee, and seven others.

The Exchange System, coordinating any number of telephone subscribers' lines, was by this time well established in permanent practise. From the engineering point of view this was the great achievement of the National Bell Telephone Company. The next problem to arise was to connect those exchanges—the problem of the Long Lines System. The first step in this direction was made on June 2, 1880, when the Directors of the American Bell Telephone Company authorized contract for building a telephone line from Boston to New York. This line was opened on March 27, 1884. On May 9, 1883, the Directors authorized the building of long distance lines between Boston, New York, Philadelphia and Washington, and between New York and Albany. The creation of the Long Lines System was to be the great achievement

of the American Bell Telephone Company, although it had to be done in an indirect way, by the formation of a special company for the purpose.

The maximum capitalization allowed the American Bell Telephone Company by the Act of the Massachusetts Legislature of March 20, 1880—\$10,000,000—was quite inadequate for the development of the business and the construction of lines on so large a scale as was rapidly becoming necessary for rendering a nation-wide service. In 1884 application was made to the Massachusetts Legislature for permission to increase the capital stock of the American Bell Telephone Company to \$30,000,000 in order to provide for these needs, but permission was refused.

THE AMERICAN TELEPHONE & TELEGRAPH COMPANY

Accordingly a new company was organized for the particular purpose of building long lines connecting the city exchanges, and incorporation was sought in another state. This was the American Telephone and Telegraph Company, chartered under the laws of the State of New York. The Articles of Association were signed on February 28, 1885, by Edward J. Hall, Jr., Thomas B. Doolittle, Joseph P. Davis and Amzi S. Dodd. The capitalization was \$100,000, of which each of the associators owned a fourth. The purpose was stated with almost exhaustive precision, to construct and operate lines all over the North American continent, not only in the United States but in Canada and Mexico, "and also by cable and other appropriate means with the rest of the known world." For the first fourteen years of its existence the American Telephone and Telegraph Company was distinctively the Telephone Company of the Long Lines.

Theodore N. Vail became the first President of the American Telephone and Telegraph Company, with Edward J. Hall, Jr., as General Manager and Angus S.

The Early Corporate Development of the Telephone

Hibbard as General Superintendent. Under their management the Long Lines System grew rapidly and became more and more important in telephone affairs. On September 17, 1887, Mr. Vail resigned the Presidency and Edward J. Hall, Jr., took his place. The growth continued.

Meantime Mr. Forbes continued as President of the American Bell Telephone Company until 1887, when he resigned. On August 10, 1887, Howard Stockton was elected President and took office on September 1st following. He in turn was succeeded on April 1, 1889, by John E. Hudson.

By 1899 it was deemed best that the American Telephone and Telegraph Company should be made the central organization. Experience had proved that conditions under the laws of the State of New York were more advantageous for the development of so great an industry as this promised to be than under the laws of the Commonwealth of Massachusetts. Increases of capitalization were allowed by the Massachusetts Legislature, in 1889 to \$20,000,000, and in 1894 to \$50,000,000, but these increases were not adequate in either case to the needs of the business which almost immediately thereafter loomed up before the company. Furthermore, with the increase of 1894 the Legislature imposed the restrictions that the new stock must be offered to stockholders, not at par, but at a market price to be fixed by the Commissioner of Corporations, and that stock remaining after that offer should be sold at auction. These were conditions which were not practical for a business of national scope. Accordingly, on December 1, 1899, the Directors of the American Bell Telephone Company voted to convey all their assets, both in stock and property, to the American Telephone and Telegraph Company in return for stock at the rate of two shares of American Telephone and Telegraph stock for one of American Bell Telephone stock. The reason for this proportion was that the value of the assets of the Ameri-

can Bell Telephone Company in this transaction was more than twice as great as the stock which represented it.

The establishment of the American Telephone and Telegraph Company as the central organization of the telephone resulted in the succeeding years and especially during the Presidency of Frederick P. Fish, from 1901 to 1907, in greatly increased development work. The telephone spread rapidly throughout the country. This, however, is another story, which does not belong to the period of the Early Corporate Development of the Telephone. Through this strenuous period of the rise of the trusts in American industry, the Telephone progressed, through competition to cooperation in the second administration of Theodore N. Vail. He federated the various telephone companies into the present Bell System. This ushered in the present period of enormous achievement, with which has come increasingly the realization of the three-fold ideal of One Policy, One System, and Universal Service.

WILLIAM CHAUNCY LANGDON.

(Note:—Mr. Langdon is with the Information Department of the American Telephone and Telegraph Company in charge of the Historical Collection—*Editor*.)

The Missouri Rate Case

THE decision of the United States Supreme Court rendered in the Southwestern Bell Telephone Company case on May 21, 1923, is of especial interest to the Bell System.

The facts out of which the case arose were as follows:

Immediately after the termination of federal control, the Commission made an order directing the Southwestern Company to show cause why the rates for exchange service and the charges for installation and moving fixed by the Postmaster General should not be reduced. In response to this order, the company made its showing. After a hearing the Commission ordered a reduction in the exchange rates and a discontinuance of the installation and moving charges.

The company took an appeal which, under the Missouri practice, went first to the Cole County Circuit Court and from it to the Supreme Court of Missouri, each court affirming the order of the Commission. Thereupon, the case was taken to the Supreme Court of the United States. That court reversed it. The majority opinion discusses two questions:

In the first place, it holds that a consideration of the greatly enhanced present costs of material, labor, supplies, etc., is essential to an honest and intelligent forecast of probable future values made upon a view of all the relevant circumstances. It finds that the Commission accorded no weight to these factors and therefore concludes that its valuation was not properly made. It should be noted that the court does not decide that present costs constitute a measure of value, or that they are the only factors to be taken into account in determining it. It only decides that these factors must be considered, so that a valuation which ignores them is not legally made. This accords with the court's earlier decisions upon this question.

The second point as to which the court finds that the

Commission was wrong is the disallowance of 55 per cent of the license contract payment. The court holds that in the absence of bad faith, or something to indicate an improper exercise of its discretion by the board of directors, whether this contract should be made and its terms, including the amount of the payment, are matters of business management within the jurisdiction of the directors and outside of the scope of regulation. In this connection the court says:

“Four and one-half per cent is the ordinary charge paid voluntarily by local companies of the general system. There is nothing to indicate bad faith. So far as appears, plaintiff in error's board of directors has exercised a proper discretion about this matter requiring business judgment. It must never be forgotten that while the State may regulate with a view to enforcing reasonable rates and charges, it is not the owner of the property of public utility companies and is not clothed with the general power of management incident to ownership. The applicable general rule is well expressed in *State Public Utilities Commission ex rel. Springfield vs. Springfield Gas and Electric Company*, 291 Ill. 209, 234.

“‘The Commission is not the financial manager of the corporation and it is not empowered to substitute its judgment for that of the directors of the corporation; nor can it ignore items charged by the utility as operating expenses unless there is an abuse of discretion in that regard by the corporate officers.’”

The opinion may be accepted as setting at rest these two important propositions.

It is a matter of interest that twenty-five years ago Mr. William Jennings Bryan, appearing for the Nebraska Commission, urged in the Supreme Court that present costs were the criterion fixing value, while on behalf of the railroad companies to which he was opposed in that case it was contended that original cost should be the basis. The court held that each of these factors, as well as all other material factors, must be taken into account. The parties aligned themselves in accordance with what each deemed to be its interest. Then reproduction cost was less than original cost. When this reversed itself the parties promptly reversed their positions.

In the Southwestern Company's case the court was unanimous in the conclusion that the case should be reversed because the rates established by the Missouri Commission were confiscatory. Mr. Justice Brandeis, however, with whom Mr. Justice Holmes concurred, filed a dissenting opinion. The argument of the dissenting opinion is that because of the difficulty in definitely fixing value and what is a fair rate of return, in lieu of these factors there should be substituted the amount prudently invested and the amount of the capital charge. It says:

"The adoption of the amount prudently invested as the rate base and the amount of the capital charge as the measure of the rate of return would give definiteness to these two factors involved in rate controversies which are now shifting and treacherous, and which render the proceedings peculiarly burdensome and largely futile. Such measures offer a basis for decision which is certain and stable."

At another place it says:

"The prime needs of the community are that facilities be ample and that rates be as low and as stable as possible. The community can get cheap service from private companies, only through cheap capital. It can get efficient service, only if managers of the utility are free to devote themselves to problems of operation and of development. It can get ample service through private companies, only if investors may be assured of receiving continuously a fair return upon the investment."

The dissenting opinion also comments upon the fact that there is a distinction between a reasonable rate and a rate that is merely compensatory, stating the established doctrine that under reasonable rates fixed by public authority an efficiently managed utility may earn much more than a mere fair return. It very aptly states that what the Constitution guarantees to the utility is not a fair return but only the opportunity to earn a fair return.

A significant thing in the dissenting opinion which should receive the most careful consideration is the reference to the fact that the present fair value and

present fair return rule of the majority opinion is a rule that may work both ways. It is said:

"To require that reproduction cost at the date of the rate hearing be given weight in fixing the rate base, may subject investors to heavy losses when the high war and post-war price levels pass—and the price trend is again downward."

Again, upon the matter of fair return, it proceeds:

"The necessary cost, and hence the capital charge, of the money embarked recently in utilities, and of that which may be invested in the near future, may be more, as it may be less, than the prevailing rate of return required to induce capital to enter upon like enterprises at the time of a rate hearing ten years hence."

This justifies the greatest emphasis upon the necessity for care and economy in the present construction of plant. Long-time financing is absolutely necessary, and it, too, must have the same careful consideration.

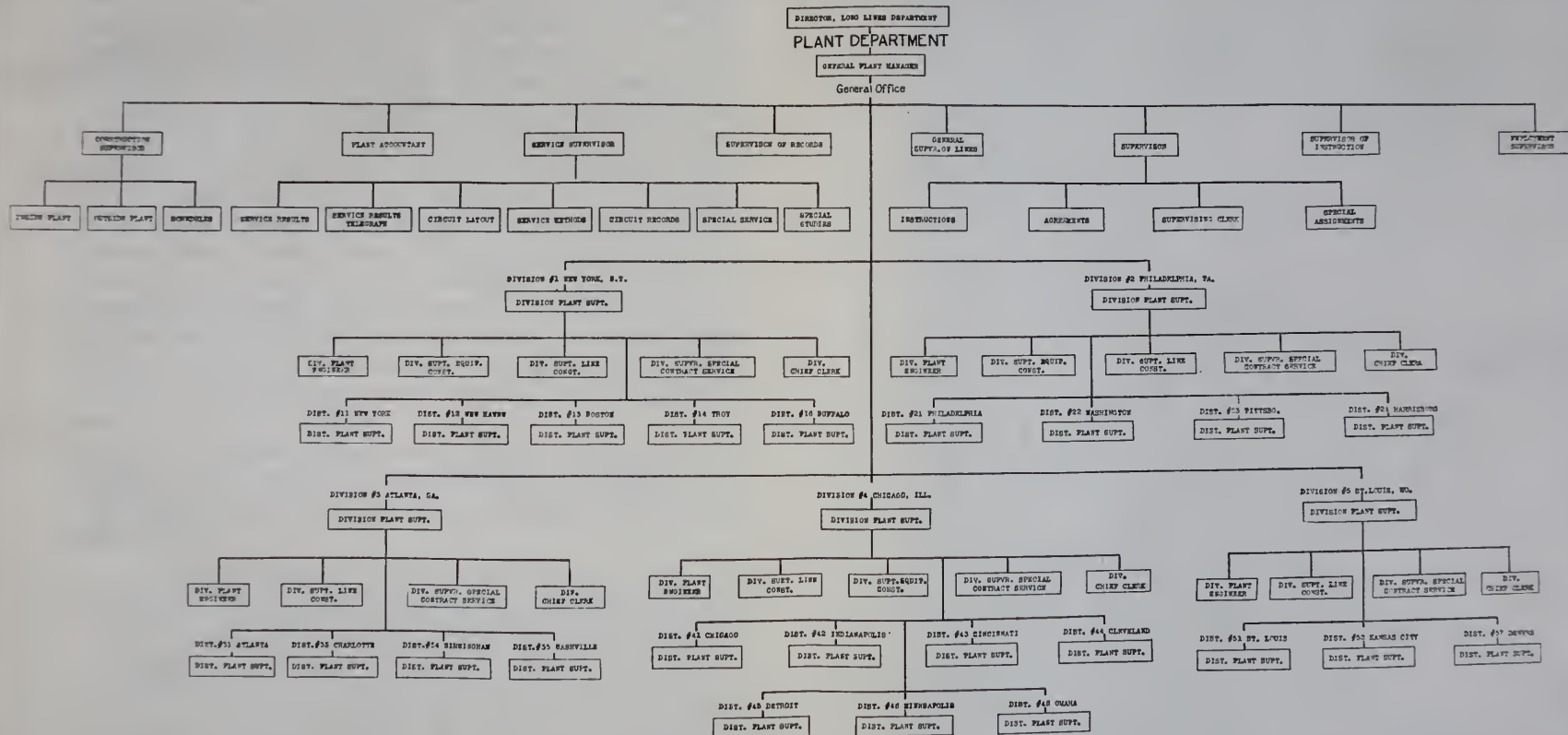
N. T. GUERNSEY.

NOTE: *Since the above was written, the United States Supreme Court, on June 11, 1923, filed its opinion in Bluefield Water Works and Improvement Company vs. Public Service Commission of the State of West Virginia et al., in which it reaffirms the decision in the Southwestern Bell Company case. It holds that it was error to disregard the cost of reproduction at current prices as a factor affecting value, citing the Southwestern Bell Company case in support of this conclusion.*

On the same day in Georgia Railway and Power Company et al. vs. Railroad Commission of Georgia et al., the court refused to reverse a case where it found that the cost of reproduction had been considered as a factor in fixing value, but had not been closely followed. This case, with the Southwestern Bell Company case and the Bluefield Water Works and Improvement Company case, sharply brings out the fact that while the cost of reproduction is a factor that must be taken into account, it does not furnish an arbitrary measure of the value of a utility.

N. T. G.

LONG LINES DEPARTMENT
OF
AMERICAN TELEPHONE & TELEGRAPH CO.
ORGANIZATION DIAGRAM OF THE PLANT DEPARTMENT
As of June 1, 1923.



The Work of the Long Lines Plant Department

WHEN a man in New York puts in a call for Chicago, Omaha, or San Francisco, he does not know or care about sleet storms in Illinois which may have shattered the telephone lines. When a man in San Francisco buys an evening paper he may want to get the closing prices on the New York Stock Exchange, or he may want the results from the baseball games at various eastern cities. There may be a flood at Pueblo or a cyclone at Omaha, but he is not interested in anything that they may be doing to the transcontinental lines. His sole interest in such events, if he has any, is as news items, and he seldom appreciates that the very fact that they have happened may be causing delay in his hearing about them, as well as delay in the transmission of other news. The Long Lines plant, existing for the sole purpose of furnishing means of communication between distant points in the United States and between the United States and points in Canada and Cuba is something which these men know very little about, but which is constantly serving them and thousands of other individuals.

In his address before the National Association of Railway and Utilities Commissioners at Detroit, in November, 1922, Mr. H. B. Thayer made the following statements:

The license contract between the American Telephone and Telegraph Company and the Associated Companies was intended to afford, and has afforded, the basis absolutely essential to a national telephone system. Aside from all questions of economy and efficiency, a national universal service could not be provided at all by a large number of uncoordinated local units. * * * It includes the obligation on the part of the American Company to construct, operate and extend the long distance lines connecting the various companies into an harmonious national operating unit. * * * Logical operating divisions are not bounded by state lines. A division between national and sectional toll lines cannot follow state lines. The undertaking

by the national organization to construct, maintain and extend the long lines is not a device for taking away from the state organizations the cream of the toll business. The long lines form one part of the national machine, designed to handle such long distance service as may be most efficiently and economically provided through this means, and so designed to make the national machine as a whole operate most efficiently and economically.

These statements define the function of the Long Lines Department in the Bell System. Within the Long Lines Department, the function of the Plant Department is the responsibility for the construction and the maintenance of the Long Lines plant, and for the operation of the special contract telegraph and telephone service. Over its circuits in 1922 passed nearly 28,000,000 long distance telephone conversations and approximately ninety per cent. of the special contract telegraph service used by press associations, newspapers, banks, brokers, manufacturers, departments of the United States Government, and business houses.

To handle these communications there are about four thousand telephone circuits and about one thousand telegraph circuits. Most of these circuits terminate in different states, many of them extend through a number of states, and some of them extend from the Atlantic to the Pacific coast. Each is an electrical circuit full of complicated equipment and requiring the most exact electrical adjustments to operate satisfactorily. From day to day, in spite of sleet storms, cyclones, fires, as well as the more numerous minor difficulties, these circuits must be kept in operation throughout the entire system if the Long Lines customers are to be satisfied and the plant is to serve the purpose for which it was constructed.

The construction problems are important and interesting, but the most important job of the Plant Department employees is to keep the plant working, i.e., maintain the service. About 4,100 times a month something happens to a wire which prevents the circuit or circuits of

which that wire forms a part from working. About 1,800 times a month something happens to one of the innumerable pieces of equipment in the circuits which prevents the circuit or circuits of which that equipment is a part from operating. These are called line and equipment troubles, respectively, and must be cleared as promptly as possible to reduce the lost circuit time. Trouble clearing, while important, is only a small part of the maintenance work. Inspections and repairs for preventing and reducing service trouble rank ahead of trouble clearing and closely allied with them is the constant work of improving the transmission efficiency of the circuits.

The plant and equipment, involving an investment of more than \$110,000,000, extends over thirty-five states, and plans for 1923 construction work contemplate extensions into three additional states. It consists of approximately 1,115,000 miles of wire including both open wires and wires in cables, with the necessary supporting structures for the open wires and cables, and of equipment for making available for service, operating, and testing the various types of telephone and telegraph circuits which are used in the Long Lines service. More than 27,000 miles of pole line, involving nearly 1,200,000 poles, support the open wires and the aerial cables and there are 867 miles of underground conduit for carrying the underground cables. Coils and circuit arrangements have made available 235,000 miles of phantom telephone circuits and loading coils have been installed on 396,000 miles of telephone circuits. Some of the principal items of equipment are:

- 1,608 sections of toll switchboard
- 384 sections of testboard
- 196 sections of Morseboard
- 2,485 telephone repeaters
 - 19 telephone carrier current channels
 - 112 telegraph carrier current channels
- 3,790 polar duplex telegraph sets
- 635 metallic telegraph sets
- 349 printing telegraph sets

The maintenance work is continuous, exacting, and because the service furnished is dependent on it, is highly important. For those reasons the District organization of the Plant Department is designed primarily to meet the service maintenance requirements and the construction work is concentrated in the five Division organizations, thereby giving each Division sufficient work to justify permanent gang organizations and allow for flexible and economical scheduling of jobs. The average length of the Long Lines circuits is so great and the investment per circuit so high that circuits in trouble mean substantial losses in revenue. For that reason the organization of the Long Lines Plant Department is set up on the basis that it is justified in maintaining the plant at the highest degree of efficiency, doing most intensive trouble prevention work and everything possible to clear troubles which cannot be prevented as rapidly as possible, thereby reducing the lost circuit time to a minimum.

The length and the complicated types of telephone and telegraph circuits operated by the Long Lines bring about the necessity for complete coordination of work and cooperation between the forces in the different territories and testrooms. Each telephone and telegraph circuit is controlled by one testroom which is known as the control office, and that office is responsible for service on the circuit. Restoration of service on any one circuit frequently involves employees in more than one Division and several Districts. To get satisfactory results they must all work together. This requires careful supervision in the handling of work and close supervision of the results obtained.

There are approximately 4,900 employees in the Department. The territory is divided into five Divisions, each in charge of a Division Plant Superintendent. The Division headquarters are located at New York, Philadelphia, Atlanta, Chicago, and St. Louis. The Divisions are further sub-divided into twenty-one Districts, each in charge of a District Plant Superintendent. While

there are no formal sub-divisions within the District, nearly all of the Districts have more than one testroom, each of which is in charge of a Chief Testboard Man, who directs the testing, the maintenance work of the section linemen and cablemen on the lines tested, and the operation of the special contract service. The equipment work in each of the larger offices is in charge of a Chief Equipment Man, who likewise reports to the District Plant Superintendent.

The District Plant Superintendent's work is distinctly a service job. He is responsible for the routine maintenance of the plant in his District and for the operation of the special contract service handled in his testrooms. Routine maintenance includes all maintenance except the pole replacement inspections which are handled by the Division offices, the pole replacement work done as a result of such inspections, which is handled by the Division gangs in connection with the construction work, and such repairs due to storms or accidental damage as are of sufficient magnitude to require the service of the Division gangs. It, of course, involves keeping the plant in his District available for service and responsibility for the transmission efficiency of the circuits controlled by the testrooms in his District.

He has a staff consisting of a Chief Clerk, a District Line Inspector, and a District Inspector, the latter being a technically trained man who assists him in supervising the maintenance work, particularly with reference to the transmission testing and the transmission efficiency of the circuits, and in handling negotiations with electric light and power companies where technical knowledge is required.

As far as possible the District Superintendent is relieved of all responsibility for construction work in order that he can devote his entire time to things which directly affect service. He is, however, expected to make recommendations for changes in plant conditions to reduce hazards and improve service conditions. He is also fre-

quently called upon by the engineers to get information needed to plan additional facilities, which he can obtain more economically than the engineers could. He also keeps in touch with road building, construction of trolley lines, electric light and power lines, and other activities which jeopardize the plant.

The open wire plant is maintained by approximately 310 section linemen. The average section consists of about ninety miles of pole line, and 1,800 miles of Long Lines wire. Most of the Associated Company wire on the Long Lines plant is also maintained by the Long Lines section linemen in connection with their own work. Similarly on Associated Company pole lines their linemen maintain Long Lines wires. With the exception of the replacement inspection of poles and the heavy replacement work done by the Division gangs, each section lineman is responsible for all maintenance work in his section and for the condition of his line. He clears line troubles under the direction of the testboard men. Each section lineman makes regular repair trips over his section at intervals depending upon the importance of the line and its exposure to severe weather conditions. On these repair trips he cuts underbrush, trims trees, cuts down dangerous trees, replaces occasional broken poles and crossarms, replaces broken pins, insulators and tie wires, and pulls up slack wire. He also reports unauthorized attachments, encroachments by electric light and power companies, prospective road work which may endanger the line or require its relocation, and any other conditions which might be considered a hazard to the line or interfere with its efficient operation. If property owners refuse to permit cutting down or trimming trees which affect the insulation, he reports such conditions so that the Legal Department may arrange for the necessary trimming rights.

On the aerial cable lines section cablemen have been placed who patrol the lines and do the routine mainte-

nance work very much in the same way that the section linemen maintain the open wire lines.

Only a few years ago Company-owned horses or livery teams were used on all trouble clearing and maintenance work, but motor vehicles have superseded horses on all Long Lines plant work. All of the section linemen and cablemen are furnished with motor vehicles for use in trouble clearing and for transporting themselves and their helpers and material to and from work. The motor vehicle equipment furnished for use on maintenance work consists of:

- 246 light runabouts fitted with boxes on the rear
- 19 light touring cars used for supervisory purposes
- 47 $\frac{3}{4}$ -ton trucks
- 33 1-ton trucks
- 7 gasoline railway speed cars

There are 380 equipment attendants reporting to Chief Equipment Men who maintain the switchboards, testboards, telephone repeaters, telegraph apparatus and other equipment. Routine tests on the various pieces of equipment are made at stated intervals and everything possible is done to keep equipment troubles from developing in service. Such troubles as do develop in service are cleared promptly.

In the testrooms, under the direction of the Chief Testboard Man, there are two large groups of employees, testboard men and telegraph repeater attendants. Testboard men make the routine morning wire tests, locate the wire troubles developed on tests or reported by the Traffic Department, and direct the movements of the section linemen who clear the troubles. They also keep track of the movements of the section linemen when they are out on repair work under the direction of the District Line Inspector, in order that instructions can be given them promptly and that they can be used for clearing troubles that may occur. Testboard men also make the routine insulation tests and resistance measurements.

The extensive use of telephone repeaters in the long distance circuits, the development of complicated cable circuits, and the introduction of carrier current telephone and telegraph circuits, all of which has taken place within the last few years, made necessary better maintenance and finer adjustments, which brought about the need for more efficient testing apparatus. This was met by the development of transmission measuring desks which have been installed in many of the testrooms. These desks permit the measurement of the actual transmission efficiency of the different circuits. Without them it would be difficult, if not impossible, to maintain satisfactory service over many of the circuits in use in the plant at the present time. Eighty-five per cent. of all of the Long Lines circuits, including all of the more complicated circuits, are now being measured regularly at transmission measuring desks.

The transmission testers who operate the transmission desks report to the Chief Testboard Man and the faults which they find in the circuits are located and cleared by his forces. The District Inspector, however, supervises their work closely and checks up the results from time to time.

The telegraph repeater attendants establish the special contract telegraph service through the different testrooms, maintain its continuity, take care of adjustments of the apparatus necessary to provide this service, and deal with the customers' operators in the regulating of the Morse signals passing over these circuits.

The Division Plant Superintendent, in addition to his responsibility for the work handled in his Districts, is also responsible for constructing the additions to plant in his Division, and such of the field engineering as is handled by the Plant Department. He is also directly responsible for the strength of the pole line structures, involving pole replacement inspections and the work found necessary as a result of such inspections. Each of the Division Plant Superintendents has a staff con-

sisting of a Division Plant Engineer, a Division Superintendent of Line Construction, a Division Supervisor of Special Contract Service, and a Division Chief Clerk. The three larger Divisions also have Division Superintendents of Equipment Construction, but in the two smaller Divisions equipment construction work is handled by the Division Plant Engineer.

The work of the Division Plant Engineer supplements the work done by the Engineer in New York. His force writes specifications for many of the construction jobs and in other cases obtains information for the Long Lines Engineering Department for use in engineering studies and in writing specifications prepared in New York. All estimates for construction, pole replacement, and break repairs are made up by the Division Engineer's force and submitted by the Division Plant Superintendent to the General Office for approval before material is ordered or work undertaken.

The Division Plant Engineer also prepares schedules for work based on the requirements of the Traffic Department or the order of importance as furnished by the Long Lines Engineer, keeps track of such schedules, and as far as his Division is concerned, under instructions from the General Plant Office, coordinates all of the construction work so that all of the different jobs necessary to complete a project may be available at the proper time. The Division Plant Engineer also assists the Division Plant Superintendent in the supervision of the maintenance work and in handling matters relating to electrolysis and inductive coordination.

The Division Chief Clerk handles the routine clerical work and is responsible for the plant accounting work done in the Division Office.

The Division Supervisor of Special Contract Service supervises the quality of service furnished the special contracts passing through his Division and keeps the Division Superintendent informed as to the quality of such service. He assists the different testrooms on

questions of improvements in this service and on certain questions of personnel. He also analyzes the different reports pertaining to message circuit troubles and poor transmission complaints on the message traffic.

The Division Construction Superintendent is responsible for handling the greater part of the additions to plant, and in connection with joint projects handles certain additions to the plant of the Associated Companies. In all of the long toll cables the Associated Companies have substantial interests. Some of this work is done by the Associated Companies and a considerable portion of the equipment construction work is done by the Western Electric Company. All of the larger new offices and all switchboard additions involving pneumatic tube work are handled by that Company.

During 1922 expenditures for gross additions to plant amounted to approximately nine and a quarter million dollars. The 1923 Provisional Estimate indicates expenditures for gross additions to plant of over thirteen million dollars. At the present time the construction force includes approximately 1,270 men. There are 67 line gangs, 5 cable gangs, 2 conduit gangs, and 31 equipment gangs. The 1923 construction program will require 48,500 poles, 178,000 crossarms, and over seven million pounds of bare copper wire.

The following motor vehicle equipment is in use by the construction forces:

- 66 light runabouts with box bodies
- 13 light touring cars for supervisory work
- 2 $\frac{3}{4}$ -ton trucks
- 3 1-ton trucks
- 13 2-ton trucks
- 44 $2\frac{1}{2}$ -ton trucks
- 5 3-ton trucks
- 12 $3\frac{1}{2}$ -ton trucks
- 2 light tractors
- 3 caterpillar tractors
- 2 earth boring machines

In the General Office of the Plant Department it has always been the policy to put out to the field all of the

work and all of the responsibility that possibly can be delegated and to maintain a small, high-grade supervisory staff.

It is not within the scope of this article to go into detail about the work of the General Office in so far as it relates to the supervision of activities for which the field forces are directly responsible. The type and extent of the Long Lines plant and the coordination of the plant facilities in the different Divisions, as well as their coordination with the plant facilities of all of the Associated Companies to form an efficient and economical national system of toll lines, make it desirable to concentrate certain work in the General Office. This work is in connection with the methods of providing the additional facilities and the best utilization of the existing facilities, and involves work by the other general offices of the Long Lines Department.

In the Plant Department much of this class of work is handled by the Service Supervisor. To handle the circuit layout work which must be done in the Plant Department requires a force of over twenty people. Members of this force attend daily meetings of the Circuit Layout Committees comprising representatives from the Engineering, Traffic, and Plant Departments. They also issue telephone and telegraph circuit layout orders, keep track of the available facilities for special contract service, answer inquiries from the Commercial Department as to whether service desired by customers can be furnished, and are continually making studies to improve the telegraph layout. Over 500 circuit orders are issued each year placing new telephone facilities in service or making changes and rearrangements in existing facilities. They have a card record of upward of 30,000 cards containing detailed records of about 3,900 telephone circuits for message business and about 215 telephone circuits for full talking circuit contracts. Details of about a thousand telegraph circuits are shown on charts which they keep.

The Construction Supervisor's work, in addition to the routine supervisory phases involving checking costs, schedules, and material requirements, includes the co-ordination of all schedules for work done in the different Divisions, either by the Division forces or for the Divisions by the Western Electric Company or an Associated Company, so that a complete project extending through various territories will not be held up by one unit of the organization.

The Supervisor of Instruction has prepared training courses in which more than eleven hundred employees are now enrolled, and supervises the carrying on of these courses.

The bulk of the work done in the General Office is supervisory. General instructions are issued covering methods and specific instructions sent out about individual items. Estimates and expenditures are checked and results are checked by reports and inspections and by comparison between territories and with results in previous years.

In planning both the organization and the work of the Plant Department, responsibility for each thing that has to be done is definitely allocated. While much of the work may seem intricate, there are simply an enormous lot of ordinary little things to be done, and the problem is to set up the best type of organization for doing them, placing definite responsibility for the different things on specific parts of the organization and arranging the organization so that things which have to be done are done promptly, economically and without duplication of effort.

There are many hundred things that can happen between the terminals of a long distance circuit which will make it impossible for that circuit to give satisfactory service to the public. It is the job of the Plant Department to see, so far as is humanly possible to do so, that none of these hundreds of things happens.

T. G. MILLER.

The Bell Public Address System

"And when they were now come where the most valiant stood, thronging about mighty Diomedes, tamer of horses, then stood forth the white-armed goddess Hera and shouted in the likeness of great-hearted Stentor with voice of bronze, whose cry was loud as the cry of fifty other men."

THE ILIAD—Homer.

THUS sung the poet, Homer, in the era of Greek mythology and his reference to Stentor, a herald of the Trojan war whose cry was loud as the voices of fifty other men, shows the inherent desire which has existed in mankind since the dawn of history to magnify the human voice. The word "stentor" has become a fixture in all languages, signifying the desire to speak so loudly as to make oneself heard throughout vast spaces.

From the time of Stentor down to a period within the last one or two years no human being has ever possessed a voice equal to this character of mythology. It remained for the Bell engineers to turn mythology into fact, and today through the Bell Public Address System any man can have the power not only of fifty voices but of fifty thousand times fifty voices.

A brief description of this very remarkable apparatus for magnifying the human voice will no doubt prove of interest. In the first place, it is necessary to have a transmitter for picking up the voice sounds which will be so sensitive as to operate when placed five or six feet distant from the speaker's lips. In addition, this transmitter must not reinforce certain of the voice tones because of resonance of its diaphragm or mouthpiece opening to these tones. The above requirements were met by the design of a transmitter operating without a mouthpiece and provided with a special alloy diaphragm which is so tightly stretched by means of a clamping ring that its natural rate of vibration is far above any of the harmonics in the human voice.

The electrical output of such a transmitter although faithfully simulating all the overtones of the human

voice represents only a very minute amount of electrical power due to the speaker being several feet away and the air waves having to act upon a highly resisting diaphragm under great tension. In order to build up this small electrical power into quantities that will successfully operate loud speaking receivers, it is necessary to bring into play that most remarkable device of the past few years, the three-electrode vacuum tube. The vacuum tube has aptly been called the "Aladdin Lamp" of the telephone, for with it today we can perform previously undreamed of feats in economical long distance telephone transmission by the successive amplification of weak telephone currents at intervals along the line.

By using a number of these vacuum tubes in series in conjunction with a considerable amount of very intricate and very complicated electrical control machinery, the volume of the minute electrical current from the transmitter before the speaker is built up several hundred million times. It has been estimated that the electrical energy delivered by a single one of the high power amplifiers of a Public Address System is sufficient to operate simultaneously at normal volume all of the twelve million telephone receivers of the Bell System in the United States.

In order to produce loud speaking results in practice, the electrical energy from the high power amplifier is delivered to specially designed telephone receivers which, on account of the large amounts of power they can absorb, may be looked upon as electrical motors for transforming electrical energy into the energy of air waves. These special receivers or projectors, as they may more properly be called, have a diaphragm made of corrugated impregnated linen which permits a wide amplitude of vibration and therefore produces intense sound waves in the adjacent air.

For amplification indoors in auditoriums, churches, banquet halls and theatres, a number of projectors are used, each one connected to a fiber horn about three feet

in length. The electrical power input to the projectors is adjusted so that the volume of sound will be comfortably loud in all parts of the auditorium. Many buildings are now being provided with permanent installations of Public Address Systems.

For outdoor occasions, the projectors are connected to square wooden horns about fifteen feet long and having a cross-section which varies from an inch at the receiver end to several feet at the mouth of the horn. A battery of eight or ten of these horns spaced uniformly around a circle when supplied with the highest power from the amplifier will enable a speaker's voice to be heard by at least five hundred thousand people gathered within a diameter of half a mile.

Some time ago one of these high power "loud speakers," as they are sometimes called, was installed experimentally in the Catskill Mountains and under favorable conditions it was possible to hear the speaker's voice for three and one-half miles through one of the mountain valleys. Not since the days of Rip Van Winkle when the mystic crew of Hendrik Hudson were reputed to play at ten-pins with thunder clouds have these peaceful valleys reverberated to such a mighty volume of sound.

The Bell Public Address System has been successfully used at many great gatherings such as the inauguration of President Harding, the Arlington ceremonies at the burial of the Unknown American, the dedication of the Lincoln Memorial and other similar occasions. At the time of the burial of the Unknown American, a total assemblage of one hundred and fifty thousand people heard every word of the Arlington ceremonies by means of loud speakers located at Arlington, New York, and San Francisco, interconnected by the Long Distance Telephone Lines.

The latest successful application of the Public Address System was the joint meeting held February 14-17, 1923, by the American Institute of Electrical Engineers in New York and Chicago. Some of the papers were pre-

sented in New York and some in Chicago, but every one in both audiences in the two cities heard all the papers and the ensuing discussions. In addition, as an extra feature, a wire connection was made to WEAJ, the Bell broadcasting station in New York, which sent out simultaneously by radio the proceedings in both cities.

As an indication of the practical value of the Bell Public Address System, the following statement of Mr. Elliot H. Goodwin, Vice-President of the National Chamber of Commerce of the United States of America, is very conclusive.

"The amplifier has become a feature of our Annual Meeting which we could not contemplate doing away with at future meetings."

In the telephone loud speaker, telephone engineers have put into the hands of civilization one of the greatest instrumentalities for good and progress. Great leaders of men of the type of Washington, Lincoln, Grant and others now have this MODERN STENTOR by means of which they can reach simultaneously by word of mouth hundreds of thousands of people many miles apart and thus promptly bind together the nation in its current affairs and in its great crises.

SERGIUS P. GRACE.

Some Personnel Problems of Foreign Telephone Systems

ON a certain occasion the Chief Electrical Engineer of a large telephone system, while visiting one of the exchanges, observed an operator in the act of disobeying instructions. The girl was summoned to the manager's office. There, in the presence of the manager, the supervisor, and the Chief Engineer, the case was stated, and the manager was requested to see that the operator did not repeat the act. The only reply the operator made was to ask that the matter be investigated by a legally constituted Board of Inquiry.

This incident, which occurred in Australia, succinctly illustrates a state of mind that is unfortunately prevalent among telephone employees in many countries. It indicates a psychological condition which arises inevitably from certain specific causes, and which as inevitably produces certain concrete results. This mental condition, its causes and its results, constitute a personnel problem which for decades has confronted, and is still confronting, the executives of many foreign telephone systems.

TELEPHONE SUCCESS DEPENDENT ON PERSONNEL

While the state of mind of the employees, their attitude toward their work and toward their superiors in the organization is of vital importance in any business undertaking, this is peculiarly true of the telephone service. The proper development, operation and extension of telephone systems is an enterprise of an intensely complex and technical character. It calls for the highest degree of ability, initiative and cooperation throughout the engineering and administrative personnel. Unless the employees work with their hearts, as well as with their heads, a satisfactory service cannot be given.

The tremendous advance of the telephone art, in this country, during the last twenty years has been made pos-

sible only by the constant employment of large numbers of competent research engineers, who are continually developing new apparatus and new methods for improving the quality and reducing the expense of telephonic communication. Engineering and organizing skill of the highest quality is required, also, for the adequate maintenance of the exceedingly intricate central office plant, the complicated web of urban telephone wires, and the tremendous stretches of long distance lines and cables, which, with the connecting network of small town systems and remote farmers' lines, make up the great nerve system of a nation-wide telephone service.

Moreover, the telephone is a natural monopoly, and this in itself entails a special responsibility toward the public. If a satisfactory service is to be given, those upon whom this responsibility rests must be men of such calibre as to insure that the policies of the organization shall be at once sound and progressive; and they must have sufficient authority to enable them to recruit and retain a staff of competent and willing subordinates. The men who construct and maintain the telephone plant and the girls who operate the switchboards should, in the interest of efficient service, be as satisfactory and as satisfied in their respective positions as are the engineering and administrative officers in theirs. Indeed, to the public, for whose service the whole organization exists, the telephone system is largely personified in the operator, and by her efficiency it is frequently judged.

PICKING THE BEST MAN FOR THE JOB

In order to maintain a satisfactory and satisfied personnel it is essential that a telephone organization should be in a position to attract the right people to its employ, to keep them after it has got them, and to eliminate any who prove to be incompetent or otherwise unsatisfactory.

A telephone corporation, operated by private enterprise, is of course able and willing to do all these things. If, for example, the Chief Engineer of such a telephone

corporation requires the services of a capable engineer for special research work, or to fill a vacancy in the organization, he can make a search for a man with the requisite qualifications, and when he finds the right man he can hire him without more ado. If it later develops that the individual selected is not, after all, the right one for the position, his superiors are entirely free to transfer him to any other work in the organization for which he appears to be adequately equipped or, if no other opportunity is available, to release him. Should he prove to be so valuable as to command greater remuneration, the men higher up can adjust his salary accordingly. It is an unfettered transaction.

CIVIL SERVICE RESTRICTIONS

In telephone systems under government ownership and operation, however, conditions are necessarily different.

If the Chief Engineer of such a telephone service wishes to take on a new man for a particular position, he is not at liberty to seek out such a man as he desires, hire him, and later promote or release him as may seem best. Like an executive in any other government department, he is necessarily restricted in all his dealings with his subordinates by the necessity of strict conformity to civil service requirements.

Civil service rules, in general, prescribe appointment by examination, promotion by rule, and security of tenure, with dismissal only for proven misconduct. While, to be sure, the details of such regulations differ somewhat in different countries, and from time to time in any one country, the general effect of the system is everywhere and always the same. It makes it difficult to fill vacancies, difficult to promote men of outstanding ability, and difficult to eliminate the unfit.

WRESTLING WITH RED TAPE

If, for example, a well qualified telephone engineer applies for a position in a government owned telephone

system, and the executives desire to employ him, they must either obtain authority to increase the staff by creating a new position, or else they must advise the applicant to enter the competition for some existing vacancy. An increase in the telephone staff, of course, means an increase in governmental expenditure, and the final decision as to taking on more men therefore rests, not with the telephone executives who are responsible for the service, but with the Treasury, or, in the last analysis, with the Parliament, which authorizes the expenditure of public funds. Permission to increase the telephone staff is, therefore, too often either refused from motives of economy, more or less irrespective of the needs of the service, or else given only after considerable delay. Even where there has been a serious shortage of staff, government telephone executives have found it expedient to wait, sometimes for months, until it has been demonstrated beyond peradventure that the shortage is permanent, before so much as requesting authority to take on new men. After permission has been granted there are still, in the words of a one time Engineer-in-Chief of the British Post Office, "a lot of little formalities to be gone through."

Vacancies, whether created by an increase in the authorized personnel or by withdrawals from the organization, must in many cases be advertised, and time allowed for the filing of applications. Examinations must be held, the examination papers read and graded, and certificates must be issued by the civil service authorities to those who pass. All in all, it is, to quote another foreign telephone official, "a somewhat tedious matter to get a staff."

Thus, although a position may be open, and the very man for the place may be available, telephone executives compelled to operate under civil service rules cannot appoint such an applicant until he has qualified in a competitive examination. These examinations, by the way, often cover literary and other educational subjects with

which an experienced technical expert may well have been long out of touch. Some civil service systems go so far as to require that all candidates for certain responsible positions start at "the same place on the ladder"; and in those cases, of course, a well qualified telephone engineer from outside the service cannot, even if he passes the examination, be given a position commensurate with his value.

INADEQUATE SALARIES

The insufficiency of government pay in the higher grades of the service is another potent influence in deterring ambitious men from taking up telephone work in countries where the wire systems are publicly owned. In Australia, in France, in Great Britain, in practically every country whose records have been examined, the complaint of inadequate salaries and "want of appreciation of men with scientific attainments" has been raised again and again. The frankest official commentary on this situation that has yet been found is recorded in the Report of the (British) Select Committee on Post Office Servants, 1907, which stated that, in the opinion of the Department, in view of the character of the work performed, "the rates of pay and the avenues of promotion were adequate"; and that "the government was obliged to tolerate, owing to Parliamentary pressure, a degree of inefficiency which in private employment would lead to dismissal of the employee."

A striking illustration of the strictness with which government departments adhere to the policy of keeping the salaries of their supervisory and technical employees within very moderate limits, was afforded by the British Post Office when it acquired the telephone system of the privately owned National Telephone Company on December 31, 1911. One of the earliest announcements made by the Post Office authorities after the decision was reached to acquire the company's business, was that

the Post Office would not take over any employee of the telephone company whose salary was in excess of £700 per annum. The Post Office had been operating the long distance telephone lines throughout Great Britain since 1896, and since 1902 had been operating a local telephone system in London as well. Nevertheless, in 1911, it was not paying, and was not willing to pay, salaries as high as those of the more important executives of the National Telephone Company. On acquiring the company's exchange system, the Post Office dispensed with the services of the most proficient telephone executives in the organization, in preference to continuing the salaries which they had earned under private enterprise.

Ten years later the scale of pay in the British postal service was still a subject of satirical comment in the London press. An official announcement of a Post Office examination covering historical, economic and scientific subjects, algebra, geometry, electricity, telegraphy and telephony, including automatic telephony and wireless, was published in a London paper, a year or two ago, under the heading: "Chance for a Genius: What the General Post Office Expects for £100 a Year."

BARRIERS TO PROMOTION

The necessary rigidity of civil service organization not only makes it difficult to attract the sort of men needed in a technical undertaking like the telephone system, but it also practically precludes the granting of such concessions as may be necessary, under certain circumstances, to keep good men in the service.

In some government services it is specifically prescribed that the basis of promotion shall be merit alone; in others both merit and seniority are to be taken into account. Under either system, however, the degree of advancement which may be granted, even to the most meritorious, is strictly limited by fixed scales of pay for fixed grades, or ranks. Moreover, in some cases increases

in salary after certain definite periods of service are made matters of right. In New Zealand the system has been carried to its logical conclusion, and postal, telegraph and telephone employees have actually been given the right to object, under certain circumstances, before a Court of Appeal, to increases in pay granted to others, if they themselves have not received like increases.

Rules governing promotion differ, to be sure, in different countries. They are, however, an essential part of every civil service system, for the very object of civil service regulation is to prevent the intrusion of politics into the public services. Were promotion left within the uncontrolled discretion of departmental executives, it is argued that it would open almost as wide a loophole for favoritism as would the abolition of competitive examinations for appointment. Yet the very rigidity of the system makes impracticable the adequate recognition of exceptional merit. Brilliant men "can do better outside"; and the inevitable tendency is, therefore, to encourage mediocrity at the expense of ability. This tendency cannot fail to have serious effects in any organization; and especially in a highly complex and technical service like the telephone business.

The telephone art is still young, and depends for its future progress upon the employment of engineers of rather exceptional ability, not only in the construction and operating departments of the service, but also in technical research. One of the commonest, and certainly one of the most costly, mistakes that governments the world over have been prone to make in the operation of business enterprises, has been the restriction of research work from motives of economy. Private enterprise has proved again and again that, in technical operations, moderate or even generous expenditures for research are far more than repaid by the savings made possible through the introduction of improved methods and equipment.

Governments, however, have been slow to recognize this truth.

DIFFICULTY OF RAISING SALARIES

Difficult as it is, under civil service regulations, to give adequate salaries to exceptional employees, it is equally difficult to give adequate salaries to ordinary employees under exceptional circumstances. The same rigidity which hinders the promotion of individuals, hampers the management in meeting the exigencies of unusual situations.

Government telephone departments in many countries have been criticized for not raising the salaries of their employees during and after the war to an extent commensurate with contemporaneous wage advances in private undertakings. It has been answered, however,—and the point is well taken—that such wage increases in private employment were for the most part temporary, whereas corresponding advances in the government service would have imposed a permanent burden upon the taxpayers. A private employer, it has been pointed out, may at any time discharge his staff and replace them with new employees at lower wages, whereas the government service is, “subject to efficiency and good conduct,” a permanent service, and its rates of pay are for permanent employment.

PROTECTION OF THE INEFFICIENT

The very fact, however, that employment in government service is permanent, “subject to efficiency and good conduct,” is a formidable stumbling block in the path of telephone executives, in many countries, for in practice this generally means that dismissal is possible only after the preferment and proof of definite charges. Of course, under government ownership this must be so if the entire service is not to be placed at the mercy of

political appointments. But however necessary it may be, telephone officials, who can neither "hire nor fire" their own assistants, have frequently testified that this limitation of their authority is directly subversive of discipline.

The incident already cited of the Australian telephone operator who, when detected by one of the principal officers of the system in the act of disobeying instructions, stood upon her rights and demanded an official investigation, is unfortunately typical of a state of mind which too often results from the knowledge that dismissal may be had only on proof of formal charges. Inefficiency, indifference, and general slackness may, indeed, be made legal grounds for removal; but these are matters which are difficult, if not impossible, to prove by legal evidence. Busy executives often prefer not to press charges of incompetence against an employee, rather than give up their time to testifying before a Board of Inquiry,—with a very good chance that, in any case, at the end of the trial the charge may be held not to have been legally proved.

In one of the official investigations of the Australia Postal Services (which include the telephone and telegraph systems) a senior inspector told of being fourteen days before such a Board, "partly under examination by defendant's solicitor." Even then, he said, the charge was not considered sustained, although he "was perfectly satisfied" that the accused employee "was guilty of incompetency."

The Royal Commission on the Australian Postal Services, which elicited this testimony (and much more to the same effect), expressed the opinion in its final report that it was "essential for the efficient working of the service that the management of the Department should be provided with more effective machinery to deal with incompetent officers."

NOT A TEMPORARY CONDITION

The condition, however, was not a temporary one. Five years after this recommendation was made, another official investigation of the Australian postal, telephone and telegraph services disclosed similar troubles; and ten years after the first investigation, "this practice of having things decided by an outside tribunal" was still being criticized in the Australian Parliament as having "tended largely to inefficiency in the (postal) service."

The fact of the matter is, of course, that difficulty in eliminating unsatisfactory government employees is a permanent condition. It is not peculiar to Australia; it is found in every country in which large staffs are employed in services operating under civil service regulations. Many responsible executives in governmental undertakings freely admit the existence of this condition, and complain bitterly of the handicap under which it places them in their relations with their subordinates. Efforts have been made from time to time in many countries to remedy the situation, but without any considerable or permanent success.

The reason is not far to seek. The condition is inherent in the system of governmental organization. It is woven into the very warp and woof of the governmental fabric. It has a very real and essential reason for existence; and if it were effectively remedied the cure would necessarily be worse than the disease.

GUARDING AGAINST THE SPOILS SYSTEM

"To the victors belong the spoils" has been a political slogan for so many years and in so many countries that it is now generally recognized that the only effective method of preventing the filling of government jobs by appointees selected under the spoils system is through unyielding adherence to the principles of civil service reform, viz.: appointment by competitive examination;

promotion according to regulations; and protection against dismissal, except for proven misconduct.

Civil service regulations have, indeed, secured continuity of employment for the rank and file of those in the public service, but this has been accomplished only by sacrificing much of the authority over the personnel which should be exercised by the responsible executives. The deleterious effect of this lack of authority is, of course, most clearly seen in branches of government service, which, like the publicly-owned telephone systems, are most directly dependent for success upon the quality of their personnel. Nevertheless, in the case of a government-owned utility, the abolition or serious weakening of civil service regulations would inevitably pave the way for still greater abuses in the shape of appointments, promotions and dismissals dictated by political considerations.

LEGISLATIVE INTERFERENCE

Even the rigidity of civil service rules seems incapable of completely eliminating Parliamentary interference in questions pertaining to departmental personnel. Government employees the world over are prone to regard their legislative representatives as a court of appeals for the redress of grievances, real or imaginary, incurred at the hands of their superiors. Of course, the greater the number of government employees, the greater is the political influence which they exercise; and the evil potentialities of the system are, therefore, greatest in those countries in which government enterprises are most extensive. Every additional industry that is nationalized swells the ranks of the civil servants, and correspondingly increases their political power and the consequent independence of their attitude toward their superiors in the government service.

Aside from direct pressure by members of Parliament in behalf of individual government employees seeking advancement or fighting dismissal, there is another form

of Parliamentary interference which takes the time of departmental executives and the money of the taxpayers, often without any very tangible benefits, viz.: legislative investigations.

Perhaps the attitude of the harassed telephone official, compelled to carry on as best he may in the face of innumerable difficulties, was never more succinctly summed up than in a remark of Sir William Noble, Engineer-in-Chief to the British Post Office in 1921, before a Parliamentary Select Committee on the Telephone Service. When asked for his opinion as to what would help to improve the general conduct of the British telephone service, Sir William replied: "The view of 99% of the officials, I believe, is 'Leave us alone to get on with the job.'"

CHANGING HEADS AND CHANGING POLICIES

Even if left strictly alone by Parliament, however, the executives of government-owned telephone systems would still be unable to lay down any general policy that would not be subject to reversal on a change of administration. The heads of government departments are necessarily cabinet ministers, and cabinet ministers obviously cannot be selected by civil service examinations. They must be appointed by the administration. Public utilities operated by government departments, therefore, necessarily face the loss of their chief executives whenever there is a change of administration; or, indeed, whenever the exigencies of party politics so require. The London press is at present publishing complaints from business men as to the prejudicial effect on the British telephone service of frequent changes in the Postmaster-Generalship, four different incumbents having held that office during the period between October, 1922, and the end of May, 1923. Of course, continuity of policy is impossible in an organization the administrative head of which is constantly changing. In the case of certain government-owned telephone systems this has had far-

reaching effects in precluding consistent adherence to any plan of development or financing, the execution of which must extend over a period of years.

CARRYING ON UNDER DIFFICULTIES

The administration of a telephone system subject to political control is certainly not an easy task. The executive in such an organization, though responsible for the conduct of a highly technical business peculiarly dependent upon its personnel, nevertheless may not select his own assistants. He may not raise their salaries in order to keep them if they are efficient. He may not dismiss them unless he is able to secure their conviction on legal evidence of misconduct. He must answer to Members of Parliament if he offends their constituents; and he must appear and testify before Boards, Commissions and Committees, until he cries, as did Sir William Noble, when Engineer-in-Chief of the British Post Office: "Leave us alone to get on with the job."

Nor are these disadvantages capable of more than temporary and partial alleviation, so long as the enterprise remains under governmental operation. Investigations are made, reforms are recommended, legislation is enacted; but in country after country, and year after year in the same country, similar difficulties are brought to light. They are inherent in the very nature of governmental organization. If the spoils system is to be avoided, there must, of necessity, be rigid civil service regulation of the appointment, promotion and dismissal of the staff. Yet the very rigidity of the civil service system, which is so discouraging to the ambitious, unavoidably causes, in the mediocre, a feeling of security against dismissal. The inevitable result of this feeling, in many individuals, is an attitude of indifference toward the work and toward the wishes and orders of the responsible executives. Once this attitude becomes widespread among the rank and file, it cannot fail to be reflected in the quality of the service rendered. In short, government departments are, by

nature, subject to deep-rooted and incurable difficulties as regards personnel which definitely unfit them for the successful operation of business enterprises.

Indeed, great credit is due to the devoted executives of government telephone systems in many countries, who have labored, and are laboring, under tremendous handicaps, to give the public as good a telephone service as can be attained under government ownership.

RICHARD STORRS COE.

NOTE: Mr. Coe is of the staff of the Chief Statistician of the American Telephone and Telegraph Company.—*Editor*.

The Telephone Directory

IN the infancy of the telephone business lists of subscribers were published, primarily to encourage the use of the telephone and invite additional patrons.

These early lists, which were the forerunners of the present day telephone directory, originally grouped the names of subscribers alphabetically under headings indicating the class of business. The first function of the telephone directory was largely one of publicity.

With the development of the business, it became impossible to handle calls by name, and number designations were introduced. As an aid to patrons in identifying telephone numbers, the business designation and street address were included with the name and telephone number as a definite part of the basic listing data, with the result that the directory took on a rather definite function in directional service.

In the beginnings of the business it was possible to include the listings of all subscribers in a single book. With the development of toll lines and increased exchange development an effort was made to continue this plan, and for several years a national telephone directory was published which contained the listings of all Bell System subscribers in the United States, between whom toll communication was possible.

As the business grew it was, however, found impracticable to continue this directory because of the number of listings involved. Accordingly, telephone directories have been developed to embrace one or more exchange areas.

REFERENCE VALUE OF THE CLASSIFIED SECTION

With increased use of the telephone, the directories came to have a service value in addition to that of telephone directional service, since by the inclusion of classified sections they furnished a certain general or business directional service formerly only provided by city and

trade directories. With the addition of the classified section, the directory has served increasingly as a business guide, directing the consumer to the supplier and the supplier to the consumer.

The expense of publishing the first directories was small, and did not materially affect the character of the book. With growth, however, directory expenses increased to the point where it became necessary to develop improved manufacturing methods, economize in the use of paper, and secure additional advertising revenues, although advertising had been included in the earliest books.

The basic information contained in the telephone directory is the listing, which includes four items—the subscriber's name, business designation, address, and telephone number. Where the size and character of the territory covered by a directory warrant, a classified section is included. In the majority of cases directories include more than a single exchange area. The scope of a given book is determined largely by the amount and distribution of traffic between given areas. Thus the directories conform to geographical areas which include localities having a definite community of interest.

PUBLIC ACCEPTANCE OF THE TELEPHONE DIRECTORY AS A BUSINESS GUIDE

At the present time telephone directories largely fill the place formerly occupied by city directories, and the classified sections of telephone directories are being used more and more as buyers' guides. There is evidence, also, that the business world of today is rapidly coming to realize the value of the data which the telephone company has accumulated as a by-product of the telephone business, and to appreciate the usefulness of this information to present day business needs.

Developments in the arts of printing and paper making have reduced unit directory expenses substantially,

but the ever increasing volume of information to be published involves costs of considerable proportions. The directory expense problem involves a balance between economy of production and service value of the book which affords a most intimate and constant contact between subscribers and the telephone company. A great deal has been accomplished in the way of economy through bulk purchases under centralized production contracts, but a point is being approached beyond which the possibility of further reductions in costs is limited unless new processes can be developed.

While revenues from directory advertising are substantial, and in recent years have been rapidly increasing to the point where directory revenues as a whole very nearly equal expenses, it seems probable that the tendency of directory practice in the future will be in the direction of furnishing more, rather than less information than at present. Directory information furnished subscribers must continue, under conditions of increasing complexity, to serve the purposes of telephone directional information.

This information must be sufficiently inclusive to furnish subscribers with listing information for as large a portion as possible of the calls they place. The introduction of machine switching calls for somewhat more explicit directory information, and the rapid growth of the telephone business present great difficulties in the way of furnishing adequate information in metropolitan districts. The increasing area of business activity as a result of growing use of toll service will require the furnishing of directory information for areas considerably outside of given local exchange areas.

Possibly the solution of these problems lies in the direction of supplementing the present type of directory by furnishing certain classes of subscribers with selected directory information, adapted to their individual or class needs, such as specialized trade directories for business uses, neighborhood directories, etc.

SOME FUTURE USES OF DIRECTORY DATA

The telephone directory contains a vast fund of valuable and currently corrected data which are not elsewhere available. This fund of general and business directional information is and probably will continue to be an increasing source of revenue through the more general publication of classified sections. This information might be used, for example, for trade directory purposes or for commodity lists such as might make it possible for national advertisers to link their products with local dealers and consumers.

It is probable that classified sections will develop along lines which will maintain the continuity of listings and increase the value of the classified section as a reference list and business guide. The classified section is approaching the status of a real buyer's guide, which is resulting in a more general use of directories and more business to the advertiser.

In general it would seem that telephone directories will develop along the line of providing a broader and more comprehensive telephone and business directional service, in order to:

(a) Meet the requirements of the steady and rapid growth of the telephone business.

(b) Furnish general and business directional service in a more complete way, and provide the means for meeting the demands of the business world, which today accepts the telephone directory as an essential medium.

(c) Discharge certain economic obligations which exist by reason of the fact that the telephone directory includes valuable data which can be made available to business generally.

(d) Supplement the telephone service program of cooperation with the telephone-using public.

It is difficult for one not immediately associated with the telephone directory problem to appreciate its magnitude. At the present time there are about 2,500 telephone directories used in the Bell System with a total annual circulation of 25,000,000 copies and requiring over 30,000 tons of paper each year.

The last national directory issued in 1897 which included the listings of all stations in the United States between which toll communication was then possible, had a page 9x12 inches and was $1\frac{1}{4}$ inches thick with a total circulation per issue of 150,000 copies requiring approximately 225 tons of paper.

To combine the listings of telephone subscribers in the United States between whom toll communication is now possible, in a single similar volume, would require a book 9 feet thick and a single issue distributed to all subscribers in the System would consume 1,500,000 tons of paper.

One issue of the 2,500 directories required today if laid end to end would reach from New York to Denver and would require for transportation about 600 freight cars of 50,000 pounds' capacity each, which, if made up into solid trains, would make 10 trains of 60 cars each.

O. C. LYON.

Abstracts of Recent Technical Papers from Bell System Sources

Radio Transmission Measurements, by Ralph Bown, C. R. Englund and H. T. Friis.¹ The paper divides naturally into three sections. The first section briefly analyses the radio transmission circuit into (a) the sending or radiating portion, (b) the transmitting portion consisting of the ether path through which the radiated waves travel, and (c) the receiving portion. The relation of these from the standpoint of the radio transmission engineer is discussed, pointing out the need of quantitative data as to electric field strengths of waves and of radio noise conditions to allow of rational design of radio systems.

The second section is devoted to descriptions of apparatus which has been developed for measuring electric field strengths of radio waves, its theory and method of use. Illustrative data are given showing useful practical results already obtained at both short and long wave lengths. The short wave length data pertain to ship-to-shore telephony and to radio broadcasting in New York City. A vector diagram is given showing the strength of signals received from three New York broadcasting stations at all quarters of the compass. The long wave length data pertain to transatlantic telephony.

The third section deals with the measurement of radio noise and a useful method is described and illustrated by data from recent transatlantic telephone tests.

Apparatus for Admitting Gas into a Vacuum,² by J. B. Johnson and H. W. Weinhart. The authors describe apparatus whereby small measured quantities of gas may be admitted to an evacuated chamber. It is essentially an inverted Toepliar pump to which a second adjustable mercury column is connected. The latter is so arranged

¹Proc. of the Inst. of Radio Engineers, April 1923.

²Journal of the Optical Society of America and Review of Scientific Instruments. Vol. 7, page 175, Feb. 1923.

that both the pressure and the volume of the admitted gas may be determined. A diagram is given which shows the arrangement of the different parts of the apparatus. They describe a method of attaching the gas reservoir which prevents loss or contamination of the gas.

Relations of Carrier and Side Bands in Radio Transmission,³ by R. V. L. Hartley. This paper discusses generally the characteristics of carrier transmission as applied in radio and in carrier current communication over wires and analyses the factors which affect the faithfulness with which such systems reproduce the signals imparted to them. It is shown that transmission of both side bands results in a certain distortion due to the beating of the various frequency components of the side bands with one another. But since the amplitude of any difference frequency is proportional to the product of the amplitudes of its two generating frequencies, the distortion can be reduced below a troublesome value by maintaining the original amplitude of the carrier sufficiently large with respect to the amplitudes of the signal components. The results indicate that the good quality which is obtained when the carrier component is large falls off very rapidly as the magnitude of the carrier component is reduced so as to approach that of a side band, the latter being measured when a sustained "ah" is used as a signal. Under these conditions the side band is maintained at a value about equal to the maximum occurring in ordinary speech.

The advantages of carrier and side band suppression are pointed out, among which are reduced distortion due to interaction of the side band components and the reduction of interference from messages on nearby wave lengths. The conclusion is reached that single side band transmission offers advantages in radio telephony while double side band transmission offers greater advantages in radio telegraphy.

³Bell System Technical Journal Apr. 1923.

The Crystal Structures of the System Palladium-Hydrogen,⁴ by L. W. McKeehan. The occlusion of hydrogen by metallic palladium at ordinary temperatures has been of interest for many years as representing an extreme case of an effect observed in many other metal-gas systems. Conflicting theories have been proposed to explain the phenomena, but hitherto no crucial experiment to decide between them has been possible. The present paper deals with measurement by means of X-rays of the form and dimensions of the palladium space-lattice with and without the presence of occluded hydrogen. It is found that very pure palladium crystals are uniformly distended by about 3.5 per cent in linear dimensions (11 per cent in volume) when saturated with hydrogen. The process is reversible, but intermediate stages are much less stable than either extreme, indicating a kind of limited miscibility. The exact positions of the hydrogen atoms was not determinable. The linear increase of electrical resistance with hydrogen content is explained. A bibliography of 66 titles is appended.

The Crystal Structure of Iron-Nickel Alloys,⁵ by L. W. McKeehan. Alloys extending from pure iron to pure nickel were examined by means of X-rays in a variety of physical conditions as obtained by cold-work and heat treatment. The body-centered-cubic space lattice of iron is predominant up to 30 per cent of nickel, the face-centered-cubic space lattice of nickel is the only one observed above this nickel content, but can be obtained in lower nickel alloys by suitable treatment. The dimensions of the crystals of either pure metal are slightly but uniformly increased by substitution of atoms of the other, suggesting certain speculations regarding the shapes of the atoms. The permalloy range of alloys is not distinguished by any abnormal type or scale of crystal structure.

⁴Physical Review, Vol. 21, pp. 334-342, March 1923.

⁵Physical Review, Vol. 21, pp. 402-407, April, 1923.

Public Address Systems,* by I. W. Green and J. P. Maxfield. A public address system comprises electrical equipment to greatly amplify a speaker's voice so it will reach a much larger assemblage than he could speak to unaided. Beginning with the presidential conventions of the two major parties in 1920 and the inaugural address of President Harding in March 1921, when a special address system installed by the telephone engineers enabled him to address an audience estimated at 125,000, there followed in rapid succession, many public events demonstrating the value of such systems. One of the most notable of these occurred on Armistice Day 1921, when the speeches, prayers and music at Arlington, Virginia, were heard, not only by 100,000 persons gathered there at the National Cemetery, but by some 35,000 in New York City and 20,000 in San Francisco. On this occasion the three public address systems, one for each of these cities, were joined by long distance telephone circuits.

The fundamental requirements of a satisfactory public address system are naturalness of reproduction and wide range of output volume. The meeting of these two requirements for music proves more difficult than for speech.

The public address system here described is most readily considered in three sections—"pick-up" apparatus which is placed in the neighborhood of the speaker and converts his words into undulatory currents; a vacuum tube amplifier for amplifying these currents; and a "receiver-projector" for reconverting the current into sound waves and distributing the sound over all of the audience. In the present system each of these three parts of the equipment has been designed with the intention of making it as nearly distortionless as possible, so that the various parts might be adaptable for audiences ranging in size from possibly one thousand to several hundred thousand, and might also be used in connection with the

*Presented at the Midwinter Convention of the A. I. E. E., New York, N. Y., February 14-17, 1923. Published in the *Journal of the A. I. E. E.* for April, 1923, and in the *Bell System Technical Journal* for April, 1923.

long distance telephone lines and with either radio broadcasting or receiving stations. One of the larger public address systems is easily capable of magnifying a speaker's voice as many as 10,000 times.

The pick-up device whether of the carbon microphone variety or a condenser transmitter need not be placed close to the speaker's lips but will operate satisfactorily when four or five feet away. The loud-speaking receiver mechanism is so designed that it will carry a power of several watts with small distortion. Under normal conditions, 40 watts distributed among a number of receiver-projectors arranged in a circle is ample to reach an audience of 700,000 persons.

*Use of Public Address System with Telephone Lines,*⁷ by W. H. Martin and A. B. Clark. The combination of the public address system and the telephone lines makes it possible for a speaker to address, simultaneously, audiences located at a number of different places. Such a combination has been used in connection with several public events and a description is given of the system as used on Armistice Day, 1921, when large audiences at Arlington, New York and San Francisco joined in the ceremonies attending the burial of the Unknown Soldier, at the National Cemetery, Arlington, Virginia.

More recently the public address system has been used in conjunction with telephone lines to attain two-way loud-speaker service. This arrangement permits the holding of joint meetings between audiences in two or more locations, separated by perhaps thousands of miles, in such a manner that speakers before each of the audiences can be heard simultaneously by the other audiences. A demonstration of two-way operation was given at the mid-winter convention of the American Institute of Electrical Engineers in February, 1923, and took the form of a joint meeting between 1,000 members in New York and 500 in Chicago.

⁷Presented at the Midwinter Convention of the A. I. E. E., New York, N. Y., February 14-17, 1923. Published in the Journal of the A. I. E. E. for April, 1923, and in the Bell System Technical Journal for April, 1923.

The electrical characteristics of any telephone line which is to be used in conjunction with loud-speaker equipment must receive special attention. In commercial telephone service the main requirement is understandability, while with the loud-speaker naturalness of reproduced speech is very important. People are accustomed to hearing through the air with very little distortion and naturally expect the same result with loud speakers. A satisfactory line for this purpose must show freedom from transients, echo effects, etc., as well as good uniformity of transmission over the proper frequency range.

The public address system, apparatus and methods has also been applied to radio broadcasting. The combination of the public address system with lines and radio makes it possible for one speaker to address enormous numbers of people located all over the country.

Impedance of Smooth Lines, and Design of Simulating Networks,⁸ by Ray S. Hoyt. The impedance characteristics of telephone lines are of considerable importance in various phases of telephone engineering; and particularly important in the applications of two-way telephone repeaters. Moreover, to permit the use of the best types of repeater circuits, impedance networks are required for closely balancing the impedances of the associated telephone lines throughout the telephonic frequency range.

This paper, which pertains only to smooth lines (as distinguished from periodically loaded lines), aims to present in a simple yet comprehensive manner the dependence of the impedance of the various types of smooth lines on the frequency and on the line constants, by means of description accompanied by equations transformed to the most suitable forms and by graphs of those equations.

Also, the paper describes the principal networks devised by the writer for simulating the impedance of the various types of smooth lines. It includes first approximation design-formulas, and outlines a supplementary semi-

⁸Bell System Technical Journal, Apr. 1923.

graphical method for arriving at the best proportioning of the networks.

Audiometric Methods and Their Applications, by E. P. Fowler, M.D., and R. L. Wegel.⁹ An audiometer is described by means of which the sensitivity of any ear can be determined at a large number of frequencies between the lower and upper limits of audibility. In this way the sensitivity of the ear for any frequency can be compared to that of the normal ear. The paper gives many conclusions, some of which are as follows:

1. In an audiogram the most serviceable scale of intensity is proportional to the logarithm of the stimulus.

2. The tone from an oscillator should be so pure that the error in reading due to the presence of harmonics is less than the observational error.

3. A current attenuator should be free from interference between the initial and attenuated currents.

4. Most commercial telephone receivers, when used in an audiometer, introduce intolerable errors.

5. Measurements made among different subjects show similarity as to general form of the curve for the two ears.

6. The two ears show close coincidence not only of form but of per cent of hearing in certain cases of similar and also of quite dissimilar lesions.

7. The curves are quite even showing no inordinate dips or rises.

8. The audiometer provides means for accurately noting the peculiarities and rate of progressive loss or improvement of hearing and also furnishes a basis for building deaf sets to bring defective auditory areas up to a given level instead of simply increasing equally the loudness of all sounds transmitted to the ear.

Signal-To-Static-Interference Ratio in RadioTelephony,¹⁰ by John R. Carson. This note discusses the signal-to-static-interference ratio in the two systems of radio telephony involving double side band transmission and single side band transmission. Considering first carrier suppression, it is stated that under ideal conditions the ratio of signal-to-static-interference can be as large in

⁹Transactions of the American Laryngological, Rhinological and Otological Society, Inc. 1922.

¹⁰Proceedings of The Institute of Radio Engineers, Vol. 2, page 271, 1923.

double side band transmission as in single but this result would be difficult to obtain in practice. The following two conclusions are given:

a. The signal-to-interference ratio in double side-band transmission with carrier *suppressed* is one-half the corresponding ratio in single side-band transmission, when account is taken of the phase and frequency variations from synchronism of the local carrier or homodyne wave.

b. The signal-to-interference ratio in double side-band transmission with carrier *transmitted* is $1/(1+c)$ times the corresponding ratio in single side-band transmission, where c is the ratio of the unmodulated carrier energy to the side-band energy in the former system.

It is stated that in practice the value of c is about two or three. Therefore in addition to the very important gain in economy of the frequency range, single side band transmission enjoys the added advantage to a very substantial gain in the signal-to-static-interference ration.

Practical Application of Carrier Telephony and Telegraphy in the Bell System,¹¹ by Arthur F. Rose. The present paper summarizes the application of carrier in the Bell System and gives typical examples of situations in which it has been found more economical than other types of facilities. Carrier systems are economical only on the longer circuits in the plant because of the cost of terminal equipment. At the present time there are nearly 15,000 channel miles of carrier telephone and 84,000 channel miles of carrier telegraph in the Bell System.

Looking forward for the next ten years, it is expected that carrier telephone facilities will be installed at the rate of about 5,000 to 10,000 channel miles and telegraph facilities at the rate of from 20,000 to 30,000 channel miles per year. In the meantime development work may produce cheaper systems which will prove in on shorter circuits thereby extending the field of use so that the rate of application may possibly be doubled or trebled.

¹¹Bell System Technical Journal, April 1923.

Notes on Recent Occurrences

GENERAL TRAFFIC CONFERENCE

THE General Traffic Conference, held at Pinehurst, N. C., April 12 to 21, was the largest and perhaps most successful general traffic conference ever held in the Bell System. In all there was a total attendance of one hundred and thirty, including not only all General Traffic Managers and Superintendents, but many of their principal staff and division men, with a large representation from the New York headquarters staff of the American Company for all or part of the conference, including Mr. Thayer, Mr. Houston, Mr. Gherardi and Mr. Hall.

At the General Traffic Conference in New York in June, 1920, emphasis was laid on the necessity and means for restoring service. At the series of special conferences early in 1921, after service had generally been restored, the keynote was economy. With service and efficiency both on a high plane of excellence now practically everywhere, the recent Pinehurst Conference dealt with both general and technical problems and was aimed to bring out the importance of maintaining a balanced performance and effecting such further improvements as seem possible both in the way of economies and in special aspects of service, and in preparing for less favorable conditions should they eventuate, particularly by strengthening personnel and public relations.

Toll service and costs and the efficient use of toll lines was a subject that was given special consideration. With toll message traffic and revenue estimated to increase well over 100% during the next ten years, the ever-increasing importance of this subject is evident. It developed as a general conclusion that average speed of toll service under normal conditions was felt to be reasonably satisfactory and that further developments in this direction lay, not so much in trying to cut a minute or so from the present average, as by eliminating the avoidable cases

of long delay and getting the service, where possible, on a more direct basis. The extension of the A-B method and its improvement, or the development possibly of some better method for handling short-haul traffic, is one of the immediate problems ahead of us. Bringing this about should both speed up the short-haul service, where the greatest demand for fast service exists, and develop latent and potential business. It also offers the best promise of ability to handle this class of business profitably. In connection with the short-haul direct handling methods, particularly tandem, the possibilities of substantial improvement in accuracy, through some form of so-called straightforward trunking, were discussed. In the matter of long-haul and switched traffic, developments along the lines of the dispatch method and improved relay methods, involving so-called operator-per-circuit plan, were discussed. The field for application of machine switching to toll lines was described and discussed. New toll switchboards will be involved in the development of these new and special operating methods, and these were discussed, as well as the likelihood of the advisability, with future increase in size of boards, of sub-dividing some of the larger units into two or more smaller ones to solve some of the supervisory and management problems.

During the next ten years toll line investment is also expected to increase and in even faster proportion than traffic. The make-up of the toll line plant will also change. Toll cable circuits have increased 190% in the last seven years as contrasted with open wire circuit growth of about 40%. There are now about 1,000,000 miles of toll cable circuit and 1,100,000 of open wire circuit, nearly half the toll circuit mileage therefore already being in cable.

In spite of the growing size and importance of toll service, the exchange service is recognized as still being the backbone of traffic work. In the local exchange work the principal immediate opportunities for improvement

were brought out as lying in minor improvements, important chiefly in their cumulative effect. In this connection emphasis was laid particularly on the desirability of considering service, not only from a technical traffic standpoint, but also, and specifically, from the viewpoint of the public. It was brought out that data now available as to auxiliary service, such as calls handled by information, multiple marking and complaint desks, and by supervisors, disclose opportunities for better methods and service on this relatively small but very important portion of the traffic work. There were papers and discussion covering practically all important phases of central office management, such as load control, force adjustment, peg count, central office instruction, selecting and training of supervisors, voice technique and quiet operating, and dependability of fundamental traffic records.

Machine switching service was covered in several discussions. Service results were reviewed both absolutely and compared with manual. Traffic engineering and operating problems and modifications in practices and organization were considered. Meeting the problems of the future will require, it was shown, not only the further development and extensive introduction of machine switching equipment but further development and extension of manual boards. It was brought out, however, that in spite of the countless difficulties which had arisen or were foreseen in connection with both development of machine switching equipment and operating practices and in the unobstructed interconnection of machine switching and manual service, successful and practical ways of meeting every difficulty arising have so far been found and thoroughly satisfactory service demonstrated as possible under all conditions.

There was very profitable interchange of ideas on the general business and employment situations throughout the country.

Some of the most important subjects of all those covered at the conference and to which more time was

devoted than to any others were both the general and specific phases of the problems arising and constructive measures being employed in Traffic Departments in furthering the aims with respect to employee representation, personnel relations and public relations.

One of the outstanding facts about this General Traffic Conference was the close agreement and unity of opinion generally regarding the main aspects of different matters discussed which seems to warrant the conclusion that traffic methods are generally on a sound basis for the attainment of the traffic objectives. This situation has come about as a result of efforts for many years to bring about sound standardization of equipment and operating and management practices, and is of special significance in view of the scope of the field which is covered in traffic operations and which was represented at this conference.

PLANT AND ENGINEERING CONFERENCE AT SHAWNEE

FROM May 15 to 24 inclusive, a conference was held at the Buckwood Inn, Shawnee-on-Delaware, Pa. attended by the Chief Engineers, the General Plant Managers and Superintendents and the Plant Methods Supervisors of the various companies comprising the Bell System in the United States and Canada; also by representatives of the Western Electric Company, the Northern Electric Company and the American Telephone and Telegraph Company.

The spirit of the conference and its purposes are well expressed in the remarks of Mr. Bancroft Gherardi, Vice President and Chief Engineer of the American Telephone and Telegraph Company, at its closing.

"If we were in a position where the System was confronted by a crisis of any kind—a crisis in regard to its operating conditions, a crisis in regard to its relations with its employees, a crisis in regard to its relations with the public, or a crisis in regard to its finance, it would be easy

to sum up and lay emphasis on the critical situation, whatever it might be. Looking at the general situation, however, as it is throughout the country, it seems to me that we are in a position which is just the reverse of having a crisis in any phase of our work. We had some exceedingly difficult situations during and after the war, but since that time things in every line of our work have been getting better, and although they are not 100 per cent, and never will be 100 per cent, and we cannot afford at any time to relax our efforts, nevertheless there is no one point upon which in my judgment it would be pertinent to lay extraordinary stress at the present time. There are, however, some points which I should like to mention. They are points that have stood out as I have listened to the discussions during the last ten days.

"The first one is—I do not know that I need to say that it has been brought to my mind many times during the conference—the very important part which the General Superintendents of Plant, the Chief Engineers and the Supervisors of Plant have in the operation of the System. They have under their care property rapidly approaching a total of 2 billion dollars. They are making additions to that property at the present time at a rate approaching 250 million dollars a year. They have under their charge, employees totaling approximately 100,000. In addition, there are perhaps 50,000 employees in the Western Electric Company. That company, as it should, being part of the System, has been represented with us throughout the whole conference.

"The next point I wish to refer to is the matter of investment per station,—its increase at the present time. I know that each of you will do all you can, and all that ought to be done to keep this investment down as far as practicable. We cannot unduly jeopardize the service; we cannot unduly jeopardize the connecting of new subscribers, but as far as consistent with these requirements, we must keep our eye on that investment.

"Toll service and the use of toll lines is a matter on

which we still have a good ways to go. As we go further, the System will be just that much better off.

"I am not going to speak of any of the specific points in regard to Plant Measurements and their use. I am just going to say that better Measurements and their use by the field people as they are made available, should, we believe, bring about more favorable results, both in the quality of the service and in the cost of rendering that service.

"Before Mr. Barnard came, I, as you know, stole his thunder on the subject of Functional Operation and General Management. He was the man who crystalized my ideas on that subject, and was the one who presented that topic to the General Managers at their conference last fall. I believe it is a point of view that should always be kept in mind, and it seems to me that your people and you yourselves, and everyone concerned, will get practically that point of view if, when considering any question to be decided, you ask yourselves this question: 'How would the General Manager decide if he had all the facts before him; not only the facts as to my part of it and my function, but the facts in regard to the effect my decision of the question may have upon the other departments, upon the public, upon the employees, and upon the showing of the Company as a whole.'

"I will not undertake to say anything about Personnel and Public Relations immediately after that which Mr. Hall, Mr. Lynch and Mr. Barnard have said on the question. All of you, and each of you, I know, have already done so much in your own respective fields, and have seen so much of the good that can come from that point of view and from that work, that it is quite unnecessary for me to add anything more to it, except to say that I do not know of anything which has been more satisfactory than watching the progress of the System along these lines during the last three years."

* * * * *

"In closing a conference such as this, I think of the

map of the United States and Canada, and of the Bell System; that map, including almost the entire area of the continent, is covered by a supervisory organization which is represented here in this room, and which, a week from now, will be scattered over that map from the East to the West, and from the North to the South.

"We have assembled here to exchange ideas, to discuss our problems, and to confer in a manner which will enable each of us to do his part of the job in such a way that ours will be indeed one System, will be the best System in the world, and that each of us will know what the others have in mind and what the others are doing, so that we may apply that knowledge to our own particular problem and get the very best results that can be obtained, considering the conditions of the local problem to be met."

* * * * *

"I know that when I go back, Mr. Thayer will ask me, 'How about the conference?' and it is a great satisfaction to me to know that I shall be glad not only to say to Mr. Thayer that in my judgment the conference was successful and helpful, but also to assure him he need have no concern as to the plant operation or the engineering of the Bell System and to further assure him that what I knew already has been confirmed by all that I have seen and heard in this conference, that is, that the plant operation and engineering forces of the System are in good and progressive hands, that good results have been obtained since our last conference, and that we are not spending much time thinking or talking about these results, except as it may help us to do still better in the future."

THE PRESIDENTS' CONFERENCE

THE presidents of the Associated Companies of the Bell System met with the executives of the American Telephone and Telegraph Company for a five-day conference at Yama Farms, on May 26th.

It was the fourth annual meeting of the System's executives to confer on plans and policies that would enable the System successfully to meet its responsibility to furnish a national telephone service of the best possible quality and at the lowest possible cost.

The progress made in reaching objectives along the lines of economy and efficiency defined at previous conferences, was found to be most encouraging.

The growth of the System was shown to be even greater than had been anticipated and on a substantial basis. Problems in connection with financing and building the plant extensions required for the continuing demand of the public for service, were discussed in detail, and improvements in means and methods of operation were carefully considered.

Much evidence was given of the high morale of the operating forces and of the increasing cooperation of telephone users due to a better understanding of the System's problems, purposes and standards. Plans were made for adding still further to the public's general knowledge of the System and for securing the public's cooperation.

Particularly interesting were the accounts of the recent developments and improvements of the communications art achieved by the System's scientists and research engineers.

A feature of the conference was the adoption of a Bell System flag which is pictured elsewhere in this magazine, to be flown from hundreds of Bell-owned buildings, to suggest the national character of the service as well as the immense physical resources of the Bell System.

A PRIVACY RADIO SYSTEM FOR CATALINA ISLAND

THE radio telephone system linking Catalina Island, thirty miles off the California coast, with Los Angeles, has been equipped with a new development of Bell System engineers which may be called a privacy

system for the radio telephone. The new system was placed in service on June 9, and the preliminary tests and actual use in service show that speech is as good in quality and volume as before its introduction, and is not intelligible to those attempting to listen to it with ordinary radio receiving apparatus.

The radio link was placed in service in 1920 when, as a result of conditions arising from the war, submarine cable was difficult to obtain and its use, although it would have provided a better grade of service at less expense, would have involved considerable delay. Suitable cable will be available in the near future and will be laid to the island, but not before the new private radio system has been given a thorough trial. Not only will the cable make it possible to handle traffic more economically and more satisfactorily in all other respects than the radio system, even with privacy assured, but it will make the ether waves now used for the radio system available for broadcasting or other essential radio services.

Heretofore the Catalina Island radio service, while providing speech transmission which has been clear and understandable to those using it, has lacked privacy, since conversations could be picked up by radio receiving stations in the neighborhood, if tuned to the proper wave length.

It was largely to remedy this situation that the privacy system was designed by engineers of the American Telephone & Telegraph Company. It is not claimed that the new system is absolutely secret but it affords privacy to the extent that conversations transmitted over it cannot be inadvertently overheard. Briefly, the messages are distorted or "scrambled" so that no receiving set not specially designed and manipulated to receive them can obtain anything intelligible.

While it is possible to design a set capable of listening to the system, such a set would be much more complicated than the ordinary set and the added complication would be of no value except for picking up transmission over

this system. The system has been likened to a lock and key, which provide practical protection against intrusion, although it may be possible to make a key which will open the lock, however complicated. While the privacy radio system does not preclude the possibility of designing a special set sufficiently like the receiving set used by the system itself to transform the message into more or less intelligible form, it does insure privacy of conversation for all practical purposes.

Not only does the wireless link connect the island with Los Angeles but, through the trunk lines of the Bell System, it puts the residents of the island in telephonic touch with every commercial center of the United States. It was part of the longest telephone circuit on record when, in the opening of the Havana-Key West submarine telephone cable, a circuit of over 5,000 miles was established, by radio, by land wires and by cable, between Catalina Island and Cuba.

IN HONOR OF THE DEAD OVERSEAS

IN honor of the Americans who lost their lives in the military service during the war, and particularly in honor of the former Bell System employees who are buried abroad, the American Telephone and Telegraph Company has made a contribution to the American Overseas Memorial Day Association Fund being raised by the American Legion.

Sixty-seven graves of former Bell System employees, buried overseas, have been definitely located and arrangements were made through representatives of the system abroad to decorate all of these last Memorial Day. In addition to these, five employees are listed as missing in action and there are eleven others as to whom information is incomplete.

AMERICAN TELEPHONE AND TELEGRAPH
COMPANY OPENS NEW BROADCASTING
STUDIOS IN NEW YORK

THE new broadcasting studios for use in connection with Station WEAJ of the American Telephone and Telegraph Company were formally opened on the evening of April 30. These studios are located at 195 Broadway, New York City, and embody important modifications adopted in an endeavor to improve the quality of broadcasting.

In July, 1922, the Company began broadcasting through Station WEAJ with a single studio located in the Walker-Lispensard Building at 24 Walker Street. Although this studio was designed in accordance with the best practice known to the radio art at that time, the experience of six months indicated desirable modifications in studio design. It was also found that the location at Walker Street was not sufficiently accessible for the many artists who take part in the broadcasting programs; consequently, the new studios are located in the Telephone and Telegraph Building at 195 Broadway. Special telephone circuits connect the studios with the radio transmitting equipment at Walker Street.

The two outstanding improvements in the new studios are: (1) means to eliminate waits in programs by the use of two studios, and (2) a more effective monitoring equipment by the installation of a novel announcer's booth.

A large studio is provided for bands, orchestras and glee clubs. A small studio is used for soloists and speakers. While an orchestra is being assembled about the microphone in the large studio, a singer or speaker is broadcasting from the small studio. When the singer has completed a number and the orchestra is ready, the large studio is switched on without any delay; hence, it is possible to alternate from one studio to the other without

lapses in the program. Artists may rest between numbers, because the necessity of singing six or seven numbers successively is eliminated.

The announcer's booth is located between the two studios and has large clear vision windows enabling the announcer to *see* what is going on in both studios. Special precautions have been taken to sound-insulate the booth so that the announcer does not *hear* directly what is going on in the studio, but within the booth is located a small monitoring loud speaker actuated by the microphone currents from the studios. Thus the announcer hears the studio music exactly as it is sent into the ether for the radio audience or, if he so desires, as rendered in the idle studio where the artists are preparing to broadcast. In this manner he controls the placing of instruments and the action of performers in the studio as determined by the radio output; that is, from the standpoint of the radio audience. This new feature eliminates the mistakes in placing of instruments which occur when the announcer or studio director is in the studio where the artists perform. His ear is not able to judge correctly what is going "on the air," from hearing the music being rendered in the studio.

A loud speaking equipment in each studio connected with the announcing microphone enables the announcer to check up the correct pronunciation of titles of selections and names of artists while broadcasting is going on from the other studio. By means of the same loud speaking equipment, introductory announcements are automatically repeated for the information of the artists about to broadcast. In this way each artist knows how and when he is introduced to the radio audience and is ready to follow the announcer promptly.

The loud speakers in the studios can be used for another purpose. When a studio is not on the air, the announcer can switch his microphone so as to actuate the loud speaker in that studio. Thus he can communicate any suggestions or instructions to the artists without

leaving his booth, in order to correct any fault observed in the placement of instruments or artists.

The reception room has been comfortably furnished to give a homelike atmosphere. A concealed loud speaking equipment gives the artists the radio program as picked up by a loop receiving set while they wait their turn to appear before the microphone.

On the opening evening a special program covering a wide range of entertainment was broadcast for the benefit of the newspaper men, music and dramatic critics and the radio editors who attended. Mr. Edgar S. Bloom, Vice-President of the American Telephone and Telegraph Company, opened the new studio and in the course of his remarks, gave a brief history of the Company's broadcasting activities.

"The American Telephone and Telegraph Company began broadcasting on July 25, 1922, on 360 meter wave length, being on the air twelve hours weekly. On October 2, 1922, we changed to 400 meter wave length, which has been used since that time and we are now broadcasting about thirty hours weekly.

"During the nine months that we have broadcast, nearly 200 of America's leading statesmen and citizens have spoken to you through WEAf, also many stars of the first magnitude in the theatrical and motion picture world. Over 200 separate programs have been broadcast involving a total of 3,000 people including artists. According to our best estimate, there are probably upwards of three-quarters of a million radio receiving sets within the area easily reached by our station and, as these sets will probably average not less than three listeners per set, we have a possible audience of between two and three million people."

BELL TELEPHONE QUARTERLY

A MEDIUM OF SUGGESTION AND A RECORD OF PROGRESS

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Some Financial Problems of Foreign Telephone Systems

A FEW months ago, there took place in France a series of public meetings, held under the auspices of the President of the French Republic, during a period designated as "Posts, Telegraph and Telephone Week." Opportunity was given at this conference for users of the communication systems of the country to voice their criticisms of the services, and to advance suggestions for their improvement. The telephone system, in particular, was the subject of severe criticism, not only from telephone users, but also from responsible government officials. It was asserted that the toll lines are so unsatisfactory as to be hardly a factor in communication in France. Some of the speakers declared that the telephone, although an instrument of everyday use in the United States, is an item of luxury in France and of very restricted value to the subscriber. Telephone service in the rural districts was described as still in its infancy.

The conference endorsed several constructive proposals. It suggested that the French government, which has had a monopoly of the telephone service throughout France since 1889, should permit the development of telephone facilities in the country districts through small cooperative companies. It also gave hearty support to

a plan which the government had placed before the French Parliament for the expenditure of 200,000,000 francs per annum, for 10 years, on the development and extension of the telephone service throughout the Republic.

Instead of authorizing the expenditure of 2,000,000-000 francs during the next 10 years, however, Parliament, in the Budget Act of June 30, 1923, has adopted a preliminary program for the investment of only 700,000,000 francs on telephone improvements, etc., during the next five years. Moreover, Parliament has specifically reserved the right to fix by annual budgetary legislation the sums which may hereafter be borrowed by the Department of Posts, Telegraphs and Telephones for purposes of general construction. Officials and others interested in the development of the French telephone system have long been urging the importance of such financial provision as would make it possible to plan ahead for the systematic improvement and extension of the system over a period of years, to meet adequately and economically the growing demand for service.

THE NEED OF LONG-TERM PLANNING

The fact that careful and intelligent long-term planning is peculiarly necessary in the telephone business has been recognized in the United States practically from the beginning of commercial telephony.

In 1878, when there were only two or three primitive telephone exchanges in operation, Alexander Graham Bell foresaw the time when a network of telephone wires would stretch from building to building and from city to city, so that "a man in one part of the country may communicate with another in a distant part." Mr. Bell urged upon prospective investors in telephone securities "the advisability of keeping this end in view, that all present arrangements of the telephone may be eventually realized in this grand system." From that day to this the development of the Bell Telephone System in the

United States has been consciously guided by a spirit of foresight, which has directed every effort toward the creation of a universal service, capable of systematic and well-balanced expansion to meet the growing needs of the public.

THE BUDGET PLAN OF THE BELL SYSTEM

In the Bell System the work of planning ahead has always been recognized as fundamental and has been organized on a highly scientific basis, until now a comprehensive five-year Budget is prepared annually which forecasts future operating and financial results and requirements in the light of the ascertained facts and tendencies of past experience, and furnishes a sound basis for a coordinated administrative program covering the succeeding five years.

In the preparation of this Budget, account is taken of expected general economic and financial conditions, of the probable future volume of business activity as a whole, of the prospective movement of general wage levels, employment conditions, interest rates, and other external factors which have an influence upon the telephone business. The probable increase in population and its distribution in cities, towns, and rural areas is carefully estimated. Surveys are made of the various classes of telephone service that may be offered to the public, and forecasts are prepared of the revenues that each class of service may reasonably be expected to produce. Pains-taking estimates are compiled of the equipment and personnel that will be needed, based on studies as to the best and most economical technical and commercial practices. Detailed studies are undertaken, not only of the plant facilities that will be required to meet the needs of the five years immediately ensuing, but also of the "back-bone" plant which must be provided during that period in order that the System may be ready to serve expeditiously and economically the larger requirements of the more distant future. In this connection it is frequently

necessary to look ahead far beyond the five-year period embraced in the formal Budget, and to forecast as accurately as possible the needs which may be expected to develop in ten, fifteen or even twenty years.

The final step in the preparation of the Budget is the translation of the program envisaged by it into terms of new capital requirements. With these requirements thus carefully determined, a well-balanced program of financing may be arranged which will assure that new funds will be available when required in adequate volume and upon economical terms. With such a well-balanced financial program, advantage may be taken of favorable market conditions for the flotation of new security issues, and the purchasing of materials and supplies may be adjusted to price movements so as to realize the greatest possible economies in this direction. It is obvious, of course, that no scheme of scientific prevision, no matter how carefully prepared, can have any considerable value if the administrators of the business cannot command the financial resources necessary to carry it out.

THE CONSTANT NEED OF NEW CAPITAL

An adequate telephone service cannot be developed in any modern community without the continual investment of large amounts of new capital. In the United States, where there is already one telephone for every 7 people, the demand for telephone service not only continues unabated, but is even increasing. Every expansion of the service gives rise to demands for still further extensions. In Great Britain, where there is only one telephone for every 47 persons; in France, where there is only one for each 76 of the population; in Germany, where there is but one telephone for every 29 people, the potential demand for telephone service is immense. In every country the telephone system must constantly expand, if the normal increase in the public's requirements is to be adequately supplied. New telephone instruments, new switchboards and other central office equipment,

new pole lines and cable must continually be furnished, and can be provided adequately and promptly only by the expenditure of new funds in considerable volume.

Moreover, the supply of new capital must not only be adequate; it must also be dependable. If comprehensive plans for future development are to be not only formulated, but actually put into operation, it must be possible for telephone executives to be certain that the money necessary to effectuate their programs will be available promptly as required. It is important that when the need for quick action arises, it should be possible for executives to go ahead without being hampered by lack of funds.

THE NEED OF ADEQUATE ACCOUNTING

While adequate financing thus contributes largely to the proper development of telephone service, it is obvious that a telephone enterprise must, to be efficient, keep systematic records of all its financial transactions; and that these records should be maintained in accordance with sound accounting practice. A capital account should be set up, and all current expenses and fixed charges arising out of the operation of the business, including adequate provision for depreciation, should be recorded as an offset to current revenues. All this might appear to be too elementary to warrant mention, were it not that in many countries adequate accounting methods have not been employed by those charged with the preparation of the financial statements of the government-owned telephone systems. Even in Great Britain, where the accounting system of the government's wire services has been very much better than that used in some other countries, the Parliamentary Select Committee on the Telephone Service in 1922 felt impelled to recommend that "the Post Office telephone accounts should be kept in a more commercial form, and more extensive use should be made of a capital account." During the past year the British Post Office, though handicapped by having four

different Postmasters-General within seven months, has been making an earnest effort to put into effect the recommendations of the Select Committee.

THE NEED OF CONTINUITY IN ADMINISTRATION

This matter of frequent changes in the responsible head of the service is, indeed, one of the principal difficulties with which governmentally operated telephone systems are forced to contend. Cabinet ministers are frequently either promoted or shelved for political reasons having nothing whatever to do with the conduct of their departments. It was pointed out years ago by a Royal Commission investigating the postal, telegraph and telephone systems operated by the Australian government that, under such circumstances, ministers are apparently anxious to signalize their occupancy of office by some new and distinct act of administration. The tendency of new Postmasters-General to make sweeping changes seems to have been corrected in the Australian service following this report, for another investigation five years later disclosed the fact that new incumbents had apparently not interfered very much with the working of the department. The official investigator, however, reported that the very fact that a new chief had the power to make changes resulted in the department's marking time until it was ascertained what his ideas were.

Another instance of the unfortunate effects of frequent changes in administration is found in the telephone service of France, where not only have the heads of the Department of Posts, Telegraphs and Telephones been constantly changing, but the form of organization itself has been frequently altered.

Conditions such as these practically preclude the carrying out, even if they do not always prevent the formulation, of far-reaching plans for telephone development and financing. Yet where the telephone service is a government monopoly the party in power is responsible to the public for conducting it, and must, in common political

fairness, be allowed to select the administrative head and to shape the policies of the department. When the opposition comes into office, however, it is not strange that its first act is frequently to discard the policies and programs of the party which it has been consistently opposing and has finally displaced. Such action may well be based on the belief that success in the election constitutes a popular mandate to effect signal alterations in governmental policy. Failure to distinguish between questions really involving governmental policy and questions of ordinary business administration, is unfortunately common enough to constitute a serious obstacle to the effective operation of telephone systems under government ownership.

OUTSIDE CONTROL OF TELEPHONE FINANCING

The executives of government telephone systems have frequently to contend, however, not only with lack of continuity in administration, but also with the even greater handicap of inability to secure adequate funds. Thus the history of the telephone in France was summed up some years ago in a report to the Chamber of Deputies as "the story of successive programs, very brilliantly conceived, but never realized for lack of resources."

The report in which this statement was made, was presented to the Chamber in 1910 by Deputy M. T. Steeg, who pointed out that dependence on annual appropriations, frequently inadequate for new construction, had greatly restricted the development of the French telephone system. He strongly urged that the telephone administration be authorized to float general loans, to use the proceeds on such construction for capital account as it might think best, and to amortize the indebtedness out of earnings during the life of the plant so constructed. As recently as last winter, Monsieur H. Milon, Chief Engineer and Director of Telephone Operation, declared that the principal reason for the inferiority of the French telephone service was the lack of any systematic or

coordinated plan in the building up of the system. He suggested that the administration be permitted to carry out a real development program, which should not be subject to the vicissitudes of yearly budgetary manipulation.

Although repeated efforts to secure the passage of the legislation suggested in 1910 have been made during the thirteen intervening years, it has remained for the present Parliament to take definite action. The Budget Act of June 30, 1923, to be sure, authorizes the Administration of Posts, Telegraphs and Telephones to float loans for construction account; but Parliament retains the right to limit the amount of such loans by annual budgetary legislation.

The dependence of government-owned telephone services upon Parliamentary authorizations is the barrier which has blocked many a well considered program of telephone development. Moreover, this barrier is unavoidable, because it is of the very essence of governmental theory and practice that not a penny shall be spent by a government department without the sanction of a definite legislative enactment.

This theory is perfectly sound. It is designed to protect the public funds from loss through dishonesty, extravagance or errors of judgment on the part of administrative officials. Legislative bodies are perfectly capable of prescribing in a fairly satisfactory way the expenditures required for the maintenance of the executive, legislative and judicial departments of government. This method of financing is one of the very foundation stones upon which governments are built. It cannot be eliminated; and, so far as concerns financial provision for the ordinary functions of government, it would be as undesirable as it would be impossible to do away with it.

This fiscal theory, however, was formulated at a time when governments practically confined themselves to the exercise of strictly governmental functions, and when their business activities were limited to the transmission

of the mails,—a service requiring little plant or fixed capital. The policy of financing by legislative appropriations was never intended to apply to the conduct of business enterprises. It is utterly unsuited to the requirements of a dynamic business. This is especially true of the telephone service, which, by its very nature, requires the constant investment of large amounts of new capital in order adequately to supply the public's requirements. This fiscal practice sharply limits the functions which governments are fitted to perform satisfactorily. It is largely because of this financial handicap that government departments are unsuitable instrumentalities for the conduct of commercial enterprises.

Of course, the details of procedure in obtaining appropriations for telephone purposes vary in different countries and at different periods in the same country. The general characteristics of the system, however, are substantially uniform, and are such as are entailed by the general acceptance of the theory that there must be no expenditure except by specific appropriation. The essential feature of the system is always the same, viz.: that the financing of the telephone system is not controlled by those who are responsible for furnishing the public with adequate telephone service.

PRUNING THE ESTIMATES

In government-owned telephone systems, the usual procedure in obtaining funds is for the executives of the telephone department to prepare detailed estimates covering the contemplated expenditures for all purposes during the ensuing fiscal year. No matter how carefully these estimates are drawn up, however, they are, in practically every country, subjected to a considerable revision by the financial officers of the government before they are even submitted to the tender mercies of Parliament. It matters not whether the reviewing authority be the Treasury or a Budgetary Committee,—in any case the revision of the telephone estimates is performed by an

official not connected with the telephone department. He is not responsible for providing satisfactory telephone service. He is, however, responsible for keeping general governmental expenditures and receipts in proper relation. When, as is too often the case, capital expenditures for telephone construction and extension must be included in the general budget of governmental outlays, the Treasury is likely to be more concerned with keeping such expenses at a minimum than with pushing telephone development. In some cases it has no choice but to scrimp the needs of the telephone service in order to provide the funds necessary for pressing military, naval or other strictly governmental requirements.

The Chief Engineer of the French telephone system pointed out, in a recent article, that the credits allowed in the budget each year for the construction of new telephone trunk lines have been growing smaller and smaller, and in 1921 and 1922 dropped to nothing at all. He explained that, "as the regulations governing public accounts preclude the incurrence of any expense before a corresponding amount of money is available therefor, it becomes utterly impossible to draw up any rational works program in advance." It is in an endeavor to remedy this situation that the new provisions regarding telephone financing were included in the recent French Budget Act.

This condition, however, has not been peculiar to France. In his annual report for 1918-19 the then Postmaster-General of Australia complained vigorously of the action of the Treasurer in reducing the Post Office Department's "bed-rock" estimates for new telephone construction. This action, the Postmaster-General declared, had placed the department in a very embarrassing position, as its officers were "at a loss to find a suitable excuse to offer prospective subscribers when refusing to provide service for them." He emphasized the fact that the service must inevitably suffer from what he characterized as a "systematic starvation policy"; and pointed out that it had been necessary to adopt unsatisfactory ex-

pedients and makeshifts, resulting in serious loss of revenue and a substantial increase in maintenance costs. Two years after this vigorous complaint, a subsequent Postmaster-General again commented in his annual report to the Governor-General of Australia on the inability of his department to obtain adequate funds for the extension of the telephone service. He asserted that this had seriously hampered the executives in their efforts to overtake arrears and to meet the ever-increasing demands of the public.

In 1922 the Australian authorities made a determined effort to remedy this condition by the adoption of a comprehensive three-year program for telegraph and telephone construction, involving a total investment of £8,498,073. Funds were made available, however, for the contemplated expenditures of the first year only; and, as under the similar French plan, Parliament retains the ultimate control over telephone financing.

PARLIAMENT AS THE FINAL AUTHORITY ON FINANCING

After the preliminary pruning by the Treasury or the Budgetary Committee, government telephone estimates are submitted to Parliament, with which rests the final determination as to the financial provision to be made. Needless to say, the members of Parliament cannot possibly be versed in the intricacies of telephone management; and if they were, they could not afford the time for an adequate investigation of the telephone needs of the country. Nor are they, any more than the Treasury, held accountable by the public for the quality of service rendered by the government telephone system. Yet it is for them to say what shall be spent on telephone development and telephone operation; and here again the need of funds for military and other expenditures tends to reduce the provision for purely business services like the telephone.

LEGISLATIVE DELAYS

Another feature of the legislative appropriation system which has proved a serious handicap to telephone executives in many countries, is the tendency to delay.

In some cases the telephone estimates have to be prepared so long in advance that by the time the money is actually made available, conditions have changed to such an extent that the appropriation has become inadequate. As the appropriation must not be exceeded, even under such circumstances, the whole tedious process has to be gone through again. Moreover, in certain countries, the annual appropriations have been made available so late in the fiscal year that they could not be wholly utilized before the end of the year, when the unexpended balance lapsed by limitation. In Great Britain and some other countries, however, "votes on account" are provided, to bridge the gap between the beginning of the fiscal year and the time when the definitive appropriations are finally passed.

Delay in the provision of funds for the purchase of current supplies, as well as for construction account, has involved some government telephone systems in heavy additional expense when purchases have had to be made on a rising market. In answer to a question asked in the Australian Parliament a year or so ago, the then Postmaster-General estimated that the price of telephone equipment for which requisitions had been submitted to the Treasury by the Post Office in 1916 and had been rejected, had since increased by an average of at least 50 per cent. So also in France, even before the financial stringency and price inflation which followed the outbreak of the war, complaint was made in a report to the Chamber of Deputies that the rigidity of the budget prevented the telephone administration from taking advantage of the opportunity to accumulate supplies, such as copper wire and insulating materials, when the market was favorable. It is only recently that an attempt has been made to remedy this situation.

FRENCH SYSTEM OF LOCAL LOANS

The French administration has long been permitted to supplement the budgetary appropriations for telephone construction by loans obtained from chambers of commerce and similar bodies in the municipalities in which the extension of telephone facilities is contemplated. These loans have supplied funds for some pressing needs; but, as has recently been pointed out by one of the high officials of the French telephone administration, money obtained in this way has had to be spent in the communities which loaned it. This system has therefore served to develop the local networks without furnishing the means for a corresponding expansion in the toll lines connecting them. As the French executive puts it: "The capillary vessels have inordinately increased, due to the lack of capacity in the main arteries, hence the congestion and delays on the large clearing circuits."

TELEPHONE DEFICITS

The effect of budgetary control over the financial operations of government-owned telephone systems, moreover, is seen not only in stunted or ill-balanced development due to the constriction of capital financing, but frequently, also, in the determination of rates by considerations other than those of a purely commercial character.

Illogical rate-making in government telephone systems has taken various forms. Perhaps its commonest manifestation is the establishment in response to popular demands, of a telephone rate structure which produces revenues inadequate to cover operating expenses, and fixed charges. In this connection it must be remembered that the operating expenses of a publicly owned telephone system are subject to augmentation as a result of uneconomical methods of operation necessitated, in many cases, by causes beyond the control of the telephone executives themselves. Under such conditions, of course, the deficits from the op-

eration of the government telephone system have to be made up out of other governmental revenues. In that case the general taxpayers are in reality compelled to meet out of their own pockets the expense of providing telephone service at less than cost for the comparatively small proportion of the community who are subscribers to the telephone service. In addition, the taxes which would have been collectible from the telephone system, had it been privately owned, are lost to the Exchequer.

Italy, for example, has been losing money on her government telephone system for years; and this is admittedly one of the impelling causes which have led the present Italian government to adopt the policy of turning over the state telephone service to private ownership and operation as soon as practicable.

Nor is the drift toward private enterprise in the field of European telephony confined to Italy. Poland has lately turned over her government telephone system to a company in which private enterprise will have a majority interest. Greece is negotiating for private operation of her national telephones. A similar attitude is manifest in Spain, and even, it is reported, in Soviet Russia. Although the French and British governments have declined to sanction proposals for the restoration of their respective Post Office telephone services to operation by private companies, there has been active agitation for such a move in both France and Britain since the war.

In many countries heavy war debts have intensified popular dissatisfaction with government telephone services which are admittedly run at a loss. Moreover, even in some cases in which it is claimed that net profits are earned on the working of government telephone systems, there is reason to believe that, if really sound accounting methods were applied, notably in the matter of providing adequately for depreciation, net deficits might be disclosed, or at any rate that the surpluses might be reduced.

The importance of keeping telephone accounts on a thoroughly sound basis has already been mentioned, but

it cannot be overemphasized. Absence or insufficient use of a capital account; failure to distinguish between expenditures for new construction and for current maintenance; lack of any adequate provision for depreciation; the keeping of accounts on a cash instead of an accrual basis; neglect to apportion overhead and other expenses among the postal, telegraph and telephone services, when these are operated by a single government department; and sometimes the lumping of the receipts from the telegraphs and the long distance telephones, are among the practices which hamper the search for comparative data on the financial results of government telephone operation in various countries.

The practice of placing both the telegraph and the telephone under Post Office management has had further anomalous results in several countries. For example, even when the financial results of the telephone and telegraph systems are shown separately, the income balance of the department as a whole seems to be regarded as the important thing. In some cases, governments have apparently been content to operate their telegraph systems at a loss for years, provided a surplus was reported on telephone operations which could be used to offset, partially or wholly, the telegraph deficits.

Again, in certain war-impooverished countries telephone rates have been increased, not with a view to meeting the financial needs of the service, but in an avowed effort to increase the general revenues of the government. From the point of view of the general fiscal policy of the state this can, no doubt, be justified as a special tax, but its effect on telephone development must be unfortunate.

“MAKING BRICKS WITHOUT CLAY”

The really serious results of attempting to finance a telephone service by the governmental system of legislative appropriations are seen, indeed, in the inadequate development of the telephone systems in many countries, which inevitably results in greatly restricting the useful-

ness of the service, even to those who are able to obtain it. It is significant that nothing has been achieved under government ownership approaching the universal service which has given the United States two-thirds of the world's telephones for the use of one-sixteenth of the world's population.

The executives of the telephone systems under government ownership are not to blame for this condition. Adequate telephone development presupposes not merely the ability to formulate wise and far-reaching plans, but also a continuity and freedom of administration rarely found in governmental enterprises, and, above all, the possession of the financial resources necessary to carry out a comprehensive program.

The financial system of legislative appropriations, an essential feature of the fiscal policy of practically every government, precludes effective long-term planning, especially in the case of a continuing service which, like the telephone system, requires the constant investment of large amounts of new capital. To the truth of this statement the gallant, but uphill fight for adequate funds which has been waged for decades by far-sighted telephone executives in various countries, bears eloquent witness. Many of them must have been tempted to exclaim, as did a certain Postmaster-General who had been denied the funds which he considered essential for the development of his country's telephone service: "I have been expected to make bricks without clay for nearly four years. To this there must inevitably be an aftermath."

RICHARD STORRS COE.

Accident Prevention and Allied Work in the Bell System

*From the Address of Mr. W. P. Elstun at the American Railway
Association, Telegraph and Telephone Section, in Colorado
Springs, Colorado, on September 19, 1923.*

BEFORE undertaking a description of the Accident Prevention and Allied Work in the Bell System, it seems desirable to briefly outline the extent of the coordinated effort involved in these activities.

There are twenty-five companies associated with the American Telephone and Telegraph Company, comprising the Bell Telephone System. These companies together with their connecting companies cover practically the entire continental United States. Because of its very nature the telephone business requires that its workers be widely scattered. They are not confined to the cities and built up communities. The miles and miles of lines extending throughout the country must be periodically inspected and must be continually maintained. Employees of the System therefore travel not only the beaten trails of humanity but penetrate the remoter sections as well.

The number of employees in the service of the Bell Telephone System is about a quarter of a million, of which some 70,000 are men in the Plant Departments. These are the men who construct and maintain the poles, wires, cables and apparatus and are the force among whom the greater majority of the accidents of the Bell System occur. It is with this force that I deal primarily in this paper.

Accident prevention has been a recognized ever present problem in the Bell System since the very early days of the business. We have always considered it largely a matter of proper cooperation between the management of the company on the one hand and the

general employee body on the other. This is probably particularly true of the telephone business because of the scattered individual employees who necessarily do not work under a constant direct supervision as do the workers of most industrial plants. These industrial workers are often congregated under a single roof with the ever watchful eye of a foreman constantly upon them. The telephone employees working individually or in small groups, as for example the installer who connects the instrument in the new subscriber's home or office are often at a considerable distance from their immediate supervisors. It is therefore obvious that in the telephone business proper teamwork between management and employees is necessary to prevent accidents.

To effect this teamwork it has been our opinion for years that both management and the employee body have certain definite responsibilities to perform and that only through the continuous performance of these responsibilities in perfect harmony and accord can the desired results be accomplished.

Briefly management's responsibilities are:

- (1) The careful selection and training of employees.
- (2) The provision of tools, materials, apparatus and methods which are safe when used with reasonable skill and care.
- (3) The establishment of adequate supervision to insure that the prescribed practices are followed.
- (4) The provision of adequate safety devices and the training of employees in first aid.
- (5) The provision of ways and means to keep alive the employees' interest in the prevention of accidents.

The employees' part in this cooperation to prevent accidents seemed to resolve itself almost solely in following the methods prescribed with reasonable skill and care and in offering suggestions that might assist.

For years we had worked upon this fundamental principle and our efforts we felt had been rewarded with no small measure of success.

With its continuous development and expansion, however, the telephone business is an ever changing art. What was best yesterday may be modified to advantage for the needs of today or to-morrow. Thus a development took place in connection with the employees' part in this cooperative movement to prevent accidents. They felt that they could aid the movement by preparing safety codes themselves, to cover the individual's personal conduct in so far as it affects the prevention of accidents, and through their own representatives they enthusiastically undertook this work.

There eventually were produced some of the most comprehensive, best illustrated booklets on "Accident Prevention" that I have ever seen.

The details of the procedure followed in preparing the codes differed somewhat between companies because the employees themselves largely worked out the plans. However, in general, the plans were along this line:

Suggestions were received from all the plant employees and these, together with records of accidents, were reviewed in turn by district and division committees. Finally all of the data from all of the divisions was passed on to a general committee which prepared a single code for the company based upon the experience of every single man in the department.

In most cases these general committees came on to New York with a draft of their code and asked us to review it with them. These reviews were made from the standpoint of coordinating the requirements of the codes with those of Federal regulations and of national associations. Naturally in this whole process of development there were contacts and conferences between the men themselves and representatives of other departments as

for example the engineering department. These engineers who were designing and developing the tools, materials and equipment, through these contacts received some first hand thoughts and suggestions from the men who were using their products and the men in turn received some scientific knowledge regarding the tools and materials which they were using that was helpful to them from an accident prevention standpoint.

The very fact that every single man in the plant department of a particular company had some part in the preparation of his particular company's code aroused a degree of interest on the part of the general employee body in accident prevention that could not have been obtained otherwise. The employee body began to realize as never before the absolute wastefulness of accidents and to appreciate that from the standpoint of the safety and well being of each individual, every man should constantly exercise care and forethought in all of his work.

FIRST AID

In conjunction with the preparation of these Safety Codes another phase of accident prevention work was undertaken which has in no small measure assisted in accomplishing the results desired. This consists in giving instruction in such features as stopping arterial bleeding, splinting broken bones, resuscitation in case of electric shock or gas asphyxiation, caring for cuts and burns, and making the patient comfortable for transportation. This First Aid training work, before general adoption throughout the system, was given a very thorough trial in one of the Associated Companies. It was found that the added knowledge, making it possible to properly care for an injured employee after an accident was only one of the benefits accruing. It developed that with this knowledge the employees became much more careful and in general, more efficient. The accident rate in the company where the training was tried out promptly began to reduce and this company has con-

sistently had about the lowest rate in the system since the work was undertaken. After training, the employees were grouped into teams of five men each, including a patient. The teams compete in preliminary, semi-final and final contests, so that eventually one team in each division is selected as the most skilled and proficient. The contests are real sporting events and the rooters are just as enthusiastic and interested as any baseball or football crowd that you have ever seen.

Later today you will have an opportunity to see a demonstration in first aid by one of the teams composed of workers right here in the Mountain States Telephone Company's territory. You can then judge how well they are equipped to serve their fellow men whenever and wherever that service is needed. I know that through the newspapers you are all familiar with the kind of work that they are doing so I just cite two clippings that are typical of the hundreds that have appeared from time to time as news items:

"First Aid came to the fore when a telephone splicer pluckily dove from a pier into the East River to save a man from drowning and then brought him back to consciousness by administering artificial respiration. The splicer is a First Aid instructor in the campaign carried on in the Bell Telephone Company."

Here is another.

"It was due to the quick thinking of Mr. Blank, a First Aid instructor of the telephone company, that a six year old boy is alive today.

The lad was watching a ball game when he fell on a broken bottle and severed an artery in his wrist.

The telephone man saw the boy being lifted into a car which was to rush him to the hospital. Leaping into the back seat as the car was about to start, Mr. Blank first checked the rush of blood by well directed pressure of his fingers, then without releas-

ing his hold, with one free hand and his teeth he fashioned a tourniquet out of two handkerchiefs; despite the jolting of the car, he succeeded in applying the tourniquet and stopped the flow of blood."

These and similar deeds were performed by some of the army of 50,000 or more trained first aid workers of the Bell System scattered all over the United States. These men are everywhere in their regular vocation, they constantly traverse the city streets, the country roads, and visit the homes, factories and business places of the country. They are provided with the skill to be at the service of the great American public in cases of life or death as well as in the communication service of the nation.

These deeds which have been cited are typical examples of the finest kind of service, that of saving a human life. I don't need to describe to you the increased prestige and standing of these men in their communities; the feeling that they have toward the Company that has assisted them in obtaining the knowledge to perform acts of this character. All of these things are apparent.

FIRST AID KITS

In conjunction with the First Aid training work, three types of first aid kits were standardized to meet the telephone companies' needs. The type of kit required depends, of course, upon the work to be performed. A large kit is provided for our heavy construction gangs and two small pocket kits, one for the splicing forces and one for the installers have been made available.

In the largest kit practically all of the items are packed in a uniform size of container and are arranged so that any one can be removed without disturbing the others. This makes for easy access and convenient inspection. On each package is illustrated the proper use of the article so that in the event that the First Aider in the excitement of an emergency forgets how to use the article, he has but to refer to the container.

COMPETITIVE FEATURE OF ACCIDENT PREVENTION

In addition to the supplying of the first aid kits and the training work in First Aid, another feature assisting in bettering teamwork and in lessening accidents had been the placing of accident prevention on a competitive basis.

To have a standard to determine just what constitutes an accident for competitive rating purposes, it was decided to include only those resulting in one full day or more lost time. All accidents are of course reported but only those involving lost time are considered in the rating. It was found that this was necessary because if all are counted, there is a tendency to avoid reporting the very minor cases. Like any game or sport where the selection of a winner rests upon a score, it is necessary, of course, that the contestants themselves understand and believe in the rating scheme, or it will fail.

In the Bell Telephone System a comprehensive report is prepared for each lost time accident occurring to an employee in the course of employment. It is used by the Associated Companies for supervisory and administrative purposes and a copy of each report is sent on to us in New York so that reviews and summaries of all cases may be prepared and made available for all.

Right at the beginning of the form is this statement: "The object of this report is to supply information to be used in preventing similar accidents in the future," and the employees are now beginning to realize that all of these data are collected so that scientific studies of accidents may be conducted with the end in view of preventing similar accidents. The reports are available for review by the employee committees to assist in their endeavor to prevent a reoccurrence, and in many cases Committees of employees themselves investigate the more serious cases and the reports of their findings are reviewed and discussed with employee groups.

The reports of the lost time accidents sent on to us in New York are reviewed and quarterly summaries

prepared, showing the "big league" standings. The teams making up the big league are the various Associated Bell Companies.

Now in addition to this big league, we have minor leagues; each Associated Bell Company prepares charts and data for the employees showing just how each division, district, etc., is comparing with the others in the particular company in respect to preventing accidents.

A real friendly competition has been established throughout the system to lessen accidents and the results accomplished are shown graphically on the chart on page 237.

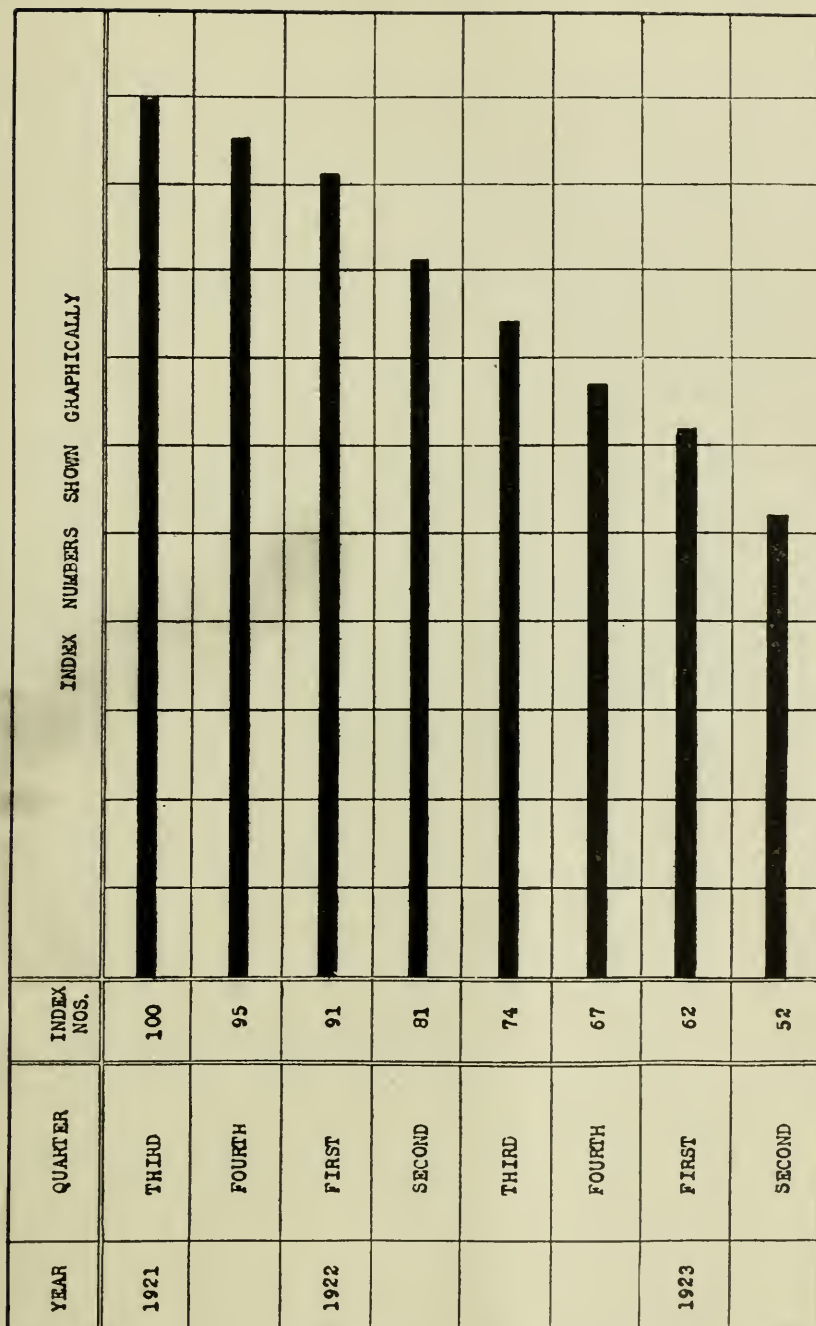
This showing is particularly gratifying when it is appreciated that we started with a comparatively low accident rate back in 1921.

AUTOMOBILE INSIGNIA

When an industry has established routines whereby fundamental data are constantly at hand for administrative purposes it is a simple matter to promptly keep in touch with changed conditions and to immediately put your finger on weak spots as they develop. The next step of course is to apply remedial measures.

Telephone work is such that tools, material, and men must constantly be transported quickly and safely and as the automobile is the modern short distance transportation medium large numbers of machines are used in the business. In the urban sections of the country with their paved highways and the constantly increasing number of motor vehicles of all character in operation, traffic is day by day becoming more congested and consequently the chance of accidents is becoming greater. As one of the measures to keep automobile accidents at a minimum it was decided to adopt a plan of placing an attractive enameled disc on the side of each car driven throughout a year without a single operating accident. Below the disc, year plates are added, one for each year which is passed without an accident.

REDUCTION IN ACCIDENT FREQUENCY RATE
BELL OPERATING COMPANIES
MAIL PLANT EMPLOYEES



INDEX NUMBERS
NOTES:—ACCIDENT FREQUENCY RATE FOR THIRD QUARTER 1921 USED AS BASE OF 100. SHOWING IS PARTICULARLY GRATIFYING WHEN IT IS APPRECIATED THAT RATE IN THIRD QUARTER 1921 WAS COMPARATIVELY LOW.

The reactions from this plan are two-fold. First, the plan interests our employees in preventing this type of accident; second, the cars so equipped passing through the cities, towns and rural communities throughout the country bring to the attention of the general public the fact that we, as a public utility, are doing our share to relieve a situation that is rapidly becoming a public menace. To show that our own people are interested in the plan, I cite just one little incident out of the many that have come to our attention.

A supervisor in one of our eastern companies heard the regular driver of a car warn a fellow employee to whom his car was temporarily assigned not to have an accident because he was out for one of those signs.

In this same company automobile operating accidents were reduced by 19 per cent. in the first year after the plan was put into effect and last year it placed awards on 75 per cent. of all of its cars. That the plan has aroused the interest of the general public has been shown by numerous comments. Here is just one of these:

A State Highway Commissioner, in a talk on highway conditions, referred specifically to the plan of the Bell System and suggested its adoption by other large automobile using concerns in his state.

OTHER ACCIDENT PREVENTION FEATURES

In addition to the features which I have already mentioned as a part of the accident prevention work a few others are of interest.

Small handbook inserts briefly outlining First Aid Practices needed in telephone work were prepared.

Guides for talks on First Aid and charts in classroom size were made available.

Then, too, series of posters were prepared, distributed and posted where our men congregated. In the development of these posters, dealing in generalities was pur-

posely avoided. Each poster was designed to forcefully illustrate one particular phase of the work which was a cause of accidents, and the subjects chosen were selected after a careful study of the accident data available. Each is of an educational nature in that it shows first a common unsafe practice to avoid, and second, how the particular operation may be performed safely.

CONCLUSION

All of these things that have been described to you are but a part of the undertakings of the Bell Telephone System in an endeavor to minimize accidents. If every one of our quarter of a million employees becomes instilled with the instinctive tendency to act with care and forethought not only in their regular vocation but in their homes and upon the public highways, and if each of these employees influences their families, friends and associates to do likewise then we feel that the Bell System has made a most substantial contribution to the general safety movement of the nation.

W. P. ELSTUN.

How the Telephone Wires Were First Put Underground

AN ACCOUNT OF THE EARLIEST CONDUIT METHODS
EMPLOYED IN THE BELL SYSTEM

LET us, in our mind's eye, turn the calendar back forty-two years. It is the last of March, 1881. Mr. W. H. Forbes, President of The American Bell Telephone Company, has just issued to the stockholders the first annual report. It is a little pamphlet of eleven pages, assuring us that the business is satisfactory and that there are upwards of 130,000 telephone instruments in the hands of the Company's licensees throughout the United States. It also shows us that Mr. Forbes and his associates clearly foresee the fast approaching day when the huge frames on the house-tops, and the towering poles on the main streets of the larger cities will suffice no longer to carry the constantly increasing burden of overhead wires. At the very beginning of the business they have inaugurated the Bell System policy of preparedness, for, says the report: "a large amount of work has been done in the electrical and experimental department—in studying the question of overhead and underground cables."

The wires must be buried, but how shall it be done? Telegraph wires, it is true, have been worked underground for many years, but, back in the Telephone Company's laboratory at Boston, a little band of electrical experts are learning that wires insulated with gutta-percha or rubber, although suitable for telegraphing, cause the telephone to work very badly, so that the voices of one's friends are frequently almost unrecognizable, the sounds being muffled and hollow, and seeming to come up out of the earth. Unexpected difficulties are met at every turn. Speaking of this period, Mr. Thomas A. Watson, Bell's earliest assistant, says, "My recollection of all this work is chiefly characterized by a feeling

How the Telephone Wires Were First Put Underground

of hopelessness I then had. I felt as if I were gazing into an abyss that must be bridged by lives of work and experiment before we could get to the other side."

But the problem of putting the wires in cables must be solved or the business will be stunted. To reinforce its own experts, the Company calls to its aid college professors of physics and of electrical theory. Experiments and tests, carried on with patient, painstaking care, begin to point the way to improvements.

A year goes by and the second annual report of the Company comes to us, saying, "Our experiments in underground cables, while not as successful as we had hoped, have given sufficient promise of satisfactory results to warrant us in undertaking a considerable expense to test the different methods. With this object, we have asked permission to put down cables in Boston, and as soon as the needed consent is obtained, we propose to make careful and thorough practical tests of the best systems offered. There is no strictly underground telephone system in any part of the world, the Paris wires being placed in huge sewers, practically large galleries, entirely altering the ordinary electrical conditions. Foreign companies are apparently waiting to see what is done in America; we have, therefore, nothing to guide us but our own experiments."

Outside of a few installations of the Brooks system of oil-insulated wires contained in buried pipes, practically all that has been done thus far with underground construction is to lay a few short lengths of cable in a wooden box covered over with pitch or asphalt. This has been done in Pittsburgh.

To carry out these underground tests in Boston will be a large and costly undertaking. Preliminary experiments are needed to throw light on some of the doubtful points, and the American Company decides to lay five miles of cable between railroad tracks in Massachusetts for no other purpose than to enable tests to be made. This is an event of importance and the *New York Review*

of the *Telegraph and Telephone*, one of the leading technical journals of the day, contains a sprightly account of the work.

"Four miles of the cable was ready for laying by Sunday, April 16, and upon that day, at half-past six in the morning, Road Master E. M. Merrill, E. F. Phillips and W. H. Sawyer, the manufacturers of the cable, and H. B. Lytle, of the Telephone Dispatch Company, were on the ground with a gang of twenty laborers, and a locomotive to which was attached a box car open at the rear end and containing the tools to be used.

"The location chosen was the Boston and Providence Railroad between the stations of Attleboro and West Mansfield, and only on Sundays is the road sufficiently free from passing trains to admit of such an extensive operation as the laying of four miles of cable, under the surface of the ground between the tracks.

"It was decided to excavate a furrow or trench for the reception of the cable, and after considering how that might be dug most expeditiously, some one hit upon the happy thought of employing a plow; some men were accordingly sent out to procure such an implement of a farmer; but the first one consulted would not allow his plow to be used on Sunday at any price, and it was some time before one was obtained. Then a heavy beam was lashed to the rear of the car, the plow was chained to that, a man seized the plow handles and the train started up, dragging the rusty share through the closely packed gravel faster than any team which ever was driven a-field. And soon a single furrow five miles in length was opened ready for the reception of the pipe.

"Inasmuch as the cable consisted of numerous sections, each five hundred and thirty feet in length, conveniences were required for connecting together the conducting wires; for this purpose, boxes were prepared into which the opposite ends of each two adjoining sections were run, and when the wires were properly connected, the boxes were made water tight and closed.

“When all the cable thus far received had been properly laid in the trench, an impromptu appliance was contrived with which to cover it up by steam; a stout plank was thrown out from the car at such an angle that when the train moved forward it would draw the gravel back into the furrow like a scraper, so that the cable was buried in a very short space of time.

“The remaining mile was laid on the subsequent Sunday with equal success, and the entire job reflects great credit on Mr. Lytle, who has had charge of the mechanical details of laying. The cable itself, weighing nearly 30 tons, filled three freight cars and was constructed as follows:

“Twenty-one conducting wires, ten of which were, besides being insulated perfectly with rubber, covered with tinfoil, which being in permanent contact with the earth through the intermediation of the enveloping pipe, is intended to conduct away any induced currents. Ten others were simply rubber-covered, and twisted together in pairs, while the twenty-first was an ordinary paraffin office wire, No. 13 gauge. The whole of the conductors are enclosed in a leaden pipe, and makes a cable three-fourths of an inch in diameter.

“The experiments with this cable will be performed by the electricians of The American Bell Telephone Company, and it is hoped will set at rest many vexed questions.”

Far from encouraging are the tests on this cable, but it is decided to go on with the Boston experiment and to construct, beneath the surface of the street, a system of ducts so that a cable which may “go bad” can be withdrawn and another pulled in to take its place. The general planning of the work is placed in the hands of Mr. J. P. Davis, an eminent civil engineer of extensive experience in the construction of water works, who appoints Mr. W. H. Sears, to act as engineer in charge of the field operations. Great care is taken at every step to ensure the permanence of the work and to exclude

water from the finished structure. Wrought iron boiler tubes, eighteen feet in length and about three inches outside diameter, are used for the ducts. Eight of these pipes are laid in a formation four wide and two high.

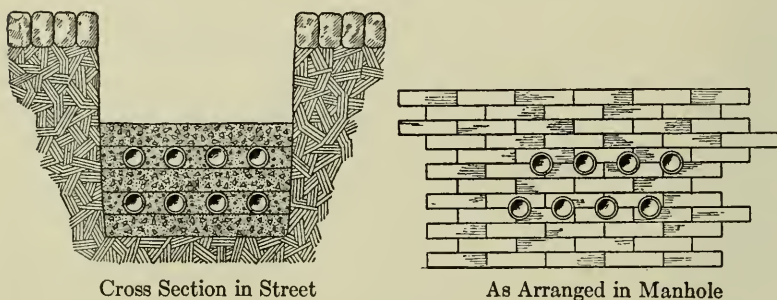


FIGURE 1

The pipes are spaced three inches apart and are surrounded with concrete three inches thick. In constructing the draw boxes or manholes, a platform of planks spiked to stringers is first laid, and on it, layer upon layer of tarred paper, liberally coated with hot tar, is used to provide a foundation upon which the brick floor rests.

MANHOLES—CONSTRUCTION

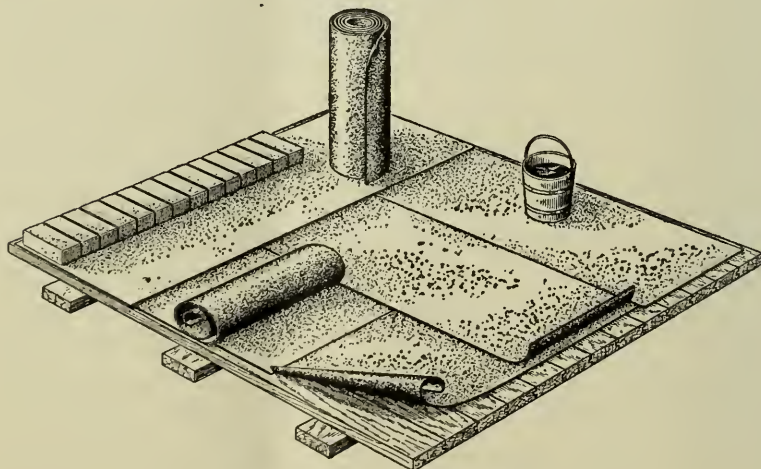


FIGURE 2—Foundation Course

How the Telephone Wires Were First Put Underground

The brick walls are made double and the space between is filled with hot tar. The ends of the pipes are laid to project about $\frac{3}{4}$ of an inch into the manholes so that, when a cable is to be drawn in, a brass bell may be screwed on to give a smooth rounded surface to draw over, thus preventing injury to the cable from the sharp edge of the pipe.

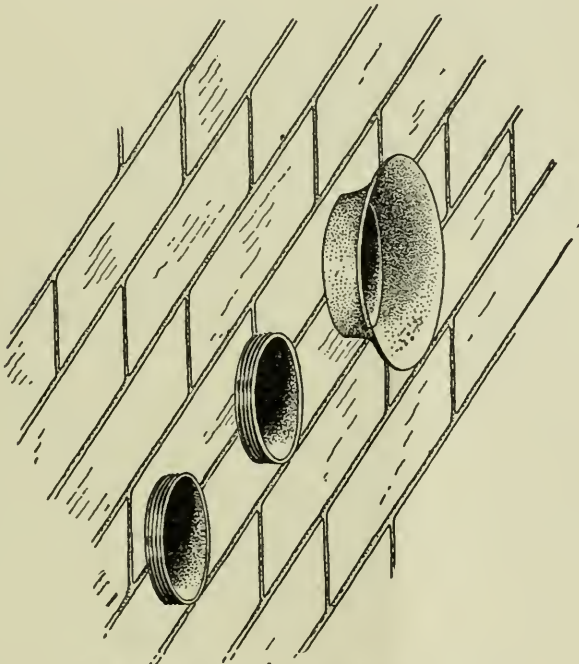


FIGURE 3—Brass Bell to Prevent Injury to Cable

As many as three cables are drawn into a single tube. Although the cables are only about a quarter of a mile long, they seriously affect the clearness of speech when talking through them from stations in the city to suburban points. The duct system in which the cables are placed is, however, a successful job.

We now witness scores of inventors directing their ingenuity to devising all sorts of schemes and plans for

placing wires underground and, in many places, the removal of the poles from the streets is being ordered without regard to the difficulties of talking over wires in cables, as yet far from being solved, thus adding man-made troubles to those imposed by the laws of Nature.

The youthful industry does what it can to meet the demand for removing the wires from the streets and house-tops. The year 1884 has come. At Washington, D. C., a ditch eighteen inches square and half a mile long is dug in the sidewalk and a board trough eight inches wide and of an equal depth is laid in it. At the bottom of the trough six cables are placed. Above these are fifty wires, some of them bare, and at the top there are ten electric light wires. Hot asphaltum is poured in, surrounding the wires and cables and forming a solid mass.

In Brooklyn, the New York and New Jersey Telephone Company has laid six Callender cables in the immediate vicinity of the exchange. They all run together about eight hundred feet from the exchange, then open out into a "Y," three cables running about one hundred feet to Washington Street and the other three to Fulton Street. Each cable contains fifty wires of No. 20 copper and is about one and a quarter inches in diameter. A light sectional iron trough is placed in a trench excavated to a depth of about thirty inches below the paving of the street. This trough is equipped with "insulite" bridges, about eighteen inches apart on which the cables rest. After the cables are laid, vulcanized bitumen—or "Bitite"—is run in so as to cement cables, bridges and trough into a solid mass.

Another year passes. It is the fall of 1885. Progress has been made in getting wires underground for short distances in the cities and in the entire Bell System there are upwards of 1,200 miles of wire underground. Let us inspect the underground plant recently completed in New York City. At the Thirty-ninth Street Exchange, lead covered cables, the wires insulated with cotton and

How the Telephone Wires Were First Put Underground

embedded in paraffin, are used. As these cables are placed in creosoted wooden boxes filled with sand, they cannot be drawn out of the conduits. Each cable contains from fifty to 100 wires. Five cables run from the exchange, through 39th Street to the corner of Seventh Avenue; three through Sixth Avenue to the corner of 42nd Street; and one to the corner of Sixth Avenue and 45th Street.

At the Twenty-first Street Exchange, the Edison system of underground wires, made by the Electrical Tube Company, is in use. There are from 100 to 270 wires in each cable. Each wire is covered with a cotton braiding treated with an insulating compound. All the wires are bunched together and placed in an iron pipe, into which asphaltum is forced, entirely surrounding the wires. The sections of iron pipe are each thirty feet in length, two sections being connected together before laying. The pipes are painted with tar and are laid four feet under the surface with a board placed on top to protect them.

The Spring Street Exchange has a Brooks System made by the Electrical Construction and Maintenance Company of Philadelphia. The wires leave the office in two 4 inch pipes, containing 380 conductors each, and are carried on, through pipes of various sizes down to $2\frac{1}{2}$ inches, to the several points where the wires are distributed on the poles. There is a cotton covering around each wire and the whole number of wires to be contained in each pipe are made into a cable. After the pipes were laid in the street, three feet underground, the cabled wires were drawn into the pipes. Then the pipes were filled with oil. The pipes rest in a wooden conduit into which pitch was poured until the conduit was filled.

Across the river in Brooklyn we find a "drawing-in" duct system constructed of creosoted wood. This was begun in 1884. The conduit is in the form of a square box, the sides, top and bottom of $1\frac{1}{2}$ inch plank, sub-

divided into ducts varying in number from ten to four, the divisions being made with one inch boards. As the manholes are not very frequent it was anticipated that trouble might be experienced in drawing in the cables. To obviate this the ducts are made three inches high by two wide and rollers are placed permanently in the bottom of each duct for the purpose of lessening friction. The conduit was made up in sections of 16 feet which were carted to the trench, dropped in, joined up and the covers screwed on.

The year 1886 arrives. The annual report again gives us a concise picture of the underground situation: "The removal of open wires from house-tops to overhead cables and to underground conduits has continued, the progress in the latter respect being especially encouraging. The system must always be a mixed one, as the final distribution of wires to the customers, and the method of reaching places where underground work would be too costly, must still be overhead; but we think that, within a few years, in all large cities the open wires will be placed in cables above or under ground to such an extent, at least as far as telephone companies are concerned, that the overhead wire nuisance will no longer be serious. In New York an amendment to the law which ordered all wires in New York City and Brooklyn underground before last November, was adopted, establishing a Commission for each of these cities with power to supervise the execution of the law, and to arrange for placing the wires underground to such an extent as might be found practicable. In Brooklyn the Commission has permitted the wire companies to begin their work, and 134 miles of underground wire have been placed there by the Telephone Company. In New York the Metropolitan Company, in August, 1885, filed with the Commission the necessary plans and statements for an underground system, and applied for permission to prosecute the work, but so far without success, and this work in that city is at present at a standstill."

How the Telephone Wires Were First Put Underground

At about this time we find several of the Associated Companies making a trial of small amounts of Dorsett Conduit, made of a mixture of asphaltum and sand.



FIGURE 4—Dorsett's Underground Conduit

This material is moulded under high pressure, while hot, into cylindrical sections three feet in length, and ten inches in diameter. Each section contains seven 2 inch holes which are made to register when adjacent sections are joined together. The year 1886 witnesses five miles of this kind of conduit being constructed under contract for the Telephone Company in Brooklyn. In 1887, after an experience of only about a year with it, Mr. Sargent, the General Manager of the New York and New Jersey Telephone Company, tells us that "The Dorsett Conduit, five miles in all connecting Brooklyn and Williamsburg, when completed proved to be very defective. The faults in it are due to several causes, but chiefly to carelessness in laying it in the ditch and making the joints. After a great deal of work, occupying all this year, the ducts are now reported ready for occupancy. The Dorsett material is very rough, and at the joints it squeezed through the cracks, making projections that were broken off in the process of clearing out, and brushes had to be run through to clear these pieces out. Even now the ducts are so very rough that a lead cable is badly scratched in hauling in. It was claimed this material was gas-tight; our experience is that it is neither gas-tight, water-tight, or even mud-tight, all of these things having been found in the ducts and manholes. The only explosion of gas we have had in Brooklyn was in a Dorsett manhole."

In Chicago, in 1886, we find, in the central district of the city, an underground route about a third of a mile in length, consisting of Patterson and Kerite cables drawn into Dorsett Conduit. Most of the wires in the business district are in cables passing over the roofs of buildings. In the north, west and south divisions of the city, however, where there are exchanges of about 600 subscribers each, there had been installed, the year before, underground cables reaching from a thousand feet to a mile away from the office. About 1,100 feet of conduit, consisting of 16 wrought iron pipes $2\frac{1}{2}$ inches in diameter and laid in concrete, is being built to carry the cables from the existing central office to a new building.

In 1887 the mileage of wire underground in the Bell System reaches a figure nearly double what it was the previous year.

The annual report for 1887 says: "It will be noted that the number of miles of wire underground has materially increased, and we expect further large additions to the underground mileage in the current year, especially in New York, where the Subway Commission has made arrangements for the working of an underground system, which will meet the requirements of the wire companies.

"The legality of the plan adopted by them has been questioned in the courts, and further legislation may be needed before the work can be completed; but, as there is a strong public desire for the burying of the wires to the greatest practicable extent, the necessary legislation will probably be obtained and the work go forward. This will involve a heavy outlay by the Metropolitan Telephone and Telegraph Company, and the subject has been under careful consideration by the directors of that Company and by our Mr. Davis; and they are prepared to put a large part of their wires into subway conduits as soon as the obstacles referred to are removed."

This underground installation in New York City is designed on the principle of keeping the electric light and power wires in subways on one side of each street, and

How the Telephone Wires Were First Put Underground

the telephone and telegraph wires in subways on the opposite side of the street. A special feature of New York subway difficulties is the steam heating underground system of which the leaks in certain localities greatly interfere with the ducts and cables, precluding the use in such places, of materials of construction which melt or soften at temperatures of about 160° to 200° Fahrenheit.

The work accomplished up to September 1, 1888, is shown in the accompanying table:

<i>Character of Ducts</i>	<i>Feet</i>
Dorsett ducts, coal tar concrete.	235,800
Zinc tubes, laid in hydraulic cement concrete.	68,900
Creosoted wood tubes.	167,200
Cement pipe, laid in hydraulic cement concrete.	216,600
Iron pipe, laid in asphaltic concrete.	131,300
Iron pipe, laid in hydraulic cement concrete.	1,423,700
Iron distributing pipe.	23,300
Edison iron tubes.	222,800
Total length of single duct.	2,489,600

The size adopted for telephone ducts is 2½ inches clear inside diameter. The manholes are all of brick, laid in cement mortar, with 8 to 12 inch walls and concrete bottoms. The street casting used has a double cover; the inner cover and rubber gasket are held down by a wrought iron cross-bar, a bolt and a padlock. The covers are practically tight against water.

The year 1889 witnesses most of the telephone companies that are putting down subways using 3 inch ducts instead of 2½ inch. In some cases creosoted wood conduits have been made using several horizontal layers of treated wood. In this type of construction the bottom layer of wood is fluted on its upper surface, intermediate layers are fluted on both their upper and lower surfaces and the top layer is fluted on its lower surface so that, when assembled in the trench, they form a square or rectangular structure with round holes for the cables. This is known as the Macdonald conduit.

Use is being made of creosoted wood conduit in the form of individual ducts, called "pump logs," each piece

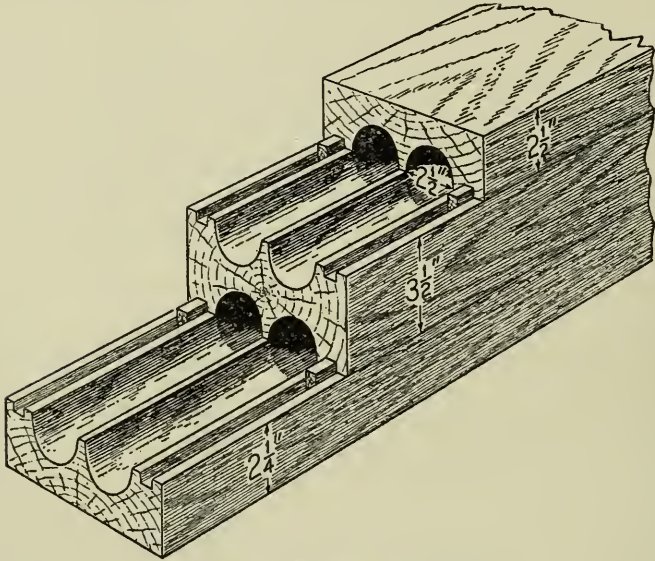


FIGURE 5—Macdonald Conduit

about $4\frac{1}{2}$ inches square with a 3 inch round bore. These are laid, as many as may be required, and in any desired cross sectional arrangement as to width and height.

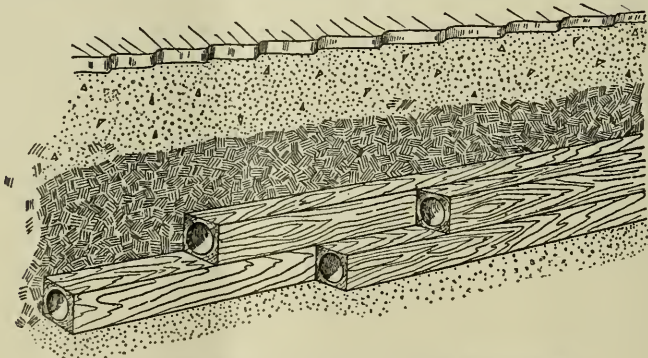


FIGURE 6—Method of Laying Creosoted Wood Ducts

Considerable use is being made of ducts constructed of sheet iron pipe lined with a coating of cement.

How the Telephone Wires Were First Put Underground

Vitrified clay or tile is coming into use. This conduit is made in sections ten inches square divided by a horizontal web or shelf into upper and lower rectangular compartments, each intended to provide space for three cables placed side by side.

About two or three years later conduits begin to be built of another form of vitrified clay, known as hollow brick. The material comes in pieces about a foot and a half long and four and a half inches square with a round hole about three inches in diameter to receive the cable. These hollow bricks are laid with cement mortar and the entire structure is then surrounded with concrete.

Another form of vitrified clay, called the multiple duct soon comes into use.

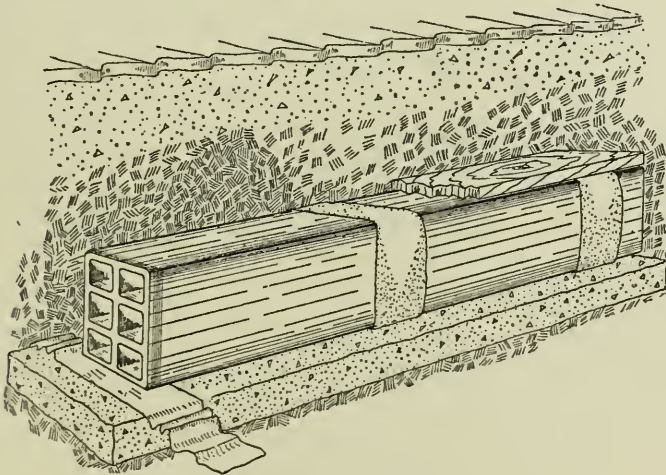


FIGURE 7—Method of Laying Multiple Duct.

This is somewhat like the “10 by 10” except that, instead of being divided into two rectangular compartments, a separate square hole is provided for each cable. Trouble was being experienced with the “10 by 10.” While three cables could generally be placed on each shelf, a cable frequently could not be withdrawn as they settled together and became jammed; also the middle

shelf would break at a manhole and continue to break back into the conduit.

Our review, covering a period of more than ten years from the beginning of the business, has now brought us to a point where underground work is settling down to the use of the general types of construction that are best adapted to endure.

* * * * *

Returning to the present time, we find that vitrified clay ducts, in either the multiple or single form, have become the principal types of underground construction employed in the Bell System. Creosoted wood ducts have proved wholly satisfactory and their use has continued where initial cost, freight rates and other factors have been such as to favor their employment. Some use is also made at the present time of wrought iron pipes where serious underground obstructions are met and the space required for other types of construction is difficult or impossible to obtain. From the humble beginnings described in the preceding pages, the underground plant has grown until we now have, in the entire Bell System, a duct mileage more than sufficient to encircle the earth twice.

The last thirty years have witnessed a continuous improvement in every portion of the underground conduit work. Engineers of the General Staff have devoted much effort to devising economies in construction methods and materials and to perfecting all portions of the work. Every precaution has been taken to insure underground structures possessing permanence and stability, thus thoroughly safeguarding the investment in them.

FREDERICK L. RHODES

World's Telephone Statistics, 1922

DURING the year 1921, 1,083,409 telephones were added to the telephone systems of the world, an increase of 5.2%, bringing the total number of telephones in the world on January 1, 1922 to 21,948,960. Of this total, 13,875,183, or 63.2%, were in the United States, of which 13,380,219, or 96%, were connected to the Bell System. The number of telephones in all the countries of Europe combined was 5,606,252, or 25.5% of the world's total; all other countries had 2,467,525, or only 11.3% of the world's telephones. At the beginning of 1922, the total number of telephones in the world was equivalent to 1.3 for each 100 of the world's population, as against 1.2 at the beginning of 1921.

These figures are taken from a compilation of the world's telephone statistics for January 1, 1922 recently completed and published by the Chief Statistician's Division of the American Telephone and Telegraph Company. Similar figures for January 1, 1921, based upon a corresponding compilation for that date, were presented in an article in *THE BELL TELEPHONE QUARTERLY* for October, 1922. Through the continued kindly co-operation of officials of foreign telephone systems, reinforced by the fact that conditions during the past year have been more nearly normal in many parts of the world, the present compilation is even more complete than its predecessor of a year ago. The accompanying tables and charts are taken from this compilation.

The table on "Telephone Development of the World, by Countries" shows that over one-half of the total net gain in telephones in the world during 1921 occurred in the United States; and this despite the fact that the extent of telephone service relative to population is very much greater in the United States than in any other country. In all Europe the gain in telephones during 1921 was only 342,085, as compared with 545,804 in the United States. On January 1, 1922, Europe still had

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES, JANUARY 1, 1922

	Number of Telephones		Per Cent of Total World	Telephones Per 100 Population	Increase in Number of Telephones during 1921†
	Government Systems	Private Companies			
NORTH AMERICA:					
United States.....	192,817	13,875,183	63.22%	12.7	545,804
Canada.....	6,672	709,273	4.11%	10.2	45,824
Central America.....	1,860	9,905	.08%	0.3	627
Mexico.....	500	43,556	.21%	0.3	632
West Indies:					
Cuba.....	560	37,538	.17%	1.3	3,662
Porto Rico.....	3,388	8,542	.04%	0.7	1,132
Other W. I. Places*.....	50	7,512	.05%	0.2	762
Other No. Am. Places*.....		3,400	.02%	0.9	250
Total.....	205,847	14,694,909	67.90%	10.1	598,693
EUROPE:					
Austria.....	132,300	.....	.60%	2.1	†
Belgium.....	80,509	.....	.37%	1.1	17,642
Bulgaria.....	6,600	.....	.03%	0.1	1,600
Czecho-Slovakia.....	81,953	.....	.37%	0.6	4,758
Denmark (March 31, 1922).....	9,869	260,757	1.23%	8.2	18,305
Finland*.....	513,307	70,000	.32%	2.1	†
France.....	1,945,601	.....	2.34%	1.3	40,095
Germany.....	997,805	.....	8.86%	3.3	136,027
Great Britain and Ireland.....	5,000	.....	4.55%	2.1	11,841
Greece*.....	62,500	.....	.02%	0.1	300
Hungary.....	82,887	.....	.28%	0.8	5,491
Italy (June 30, 1921).....	21,698	37,214	.55%	0.3	5,124
Jugo-Slavia.....	175,027	.....	.10%	0.2	5,259
Netherlands.....	85,514	.....	.80%	2.5	14,091
Norway (June 30, 1921).....	50,118	.....	.69%	5.7	16,970
Poland.....	1,890*	.....	.35%	0.3	5,469
Portugal.....	28,000	.....	.08%	0.3	1,288
Roumania (March 31, 1922)*.....	170,741	.....	.13%	0.2	3,299
Russia.....	9,600	.....	.78%	0.1	†
Spain*.....	383,877	.....	.38%	0.4	12,500
Sweden.....	161,705	.....	1.76%	6.5	2,527¶
Switzerland.....	44,237	.....	.74%	4.2	9,369
Other Places in Europe*.....		.....	.21%	0.3	15,184
Total.....	5,050,738	5,606,252	25.54%	1.2	342,085

*Partly estimated. †Minus sign preceding a figure denotes decrease.

‡Accurate data not available, and basis for reliable estimate lacking. An arbitrary estimate, however, is included in total for Europe.

¶Decrease caused by consolidation of telephone plants in Stockholm.

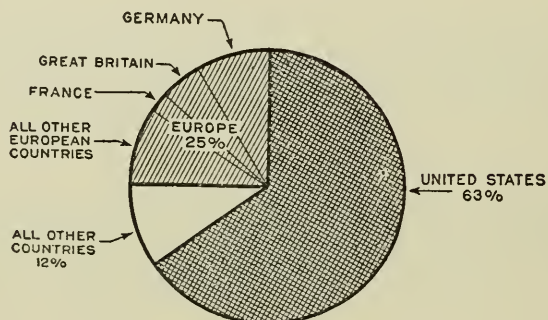
	Government Systems	Number of Telephones		Per Cent of Total World	Telephones Per 100 Population	Increase in Number of Telephones during 1921†
		Private Companies	Total			
SOUTH AMERICA:						
Argentina.....	.....	130,727	130,727	.59%	1.5	14,174
Bolivia.....	.....	2,609	2,609	.01%	0.1	92
Brazil.....	1,247	86,339	87,586	.40%	0.3	2,495
Chile.....	.....	29,661	29,661	.13%	0.7	—206
Colombia.....	.....	7,301	7,301	.03%	0.1	458
Ecuador.....	1,425	2,611	4,036	.02%	0.2	90
Paraguay.....	86	320	406	.002%	0.04	0
Peru.....	2	8,619	8,621	.04%	0.2	69
Uruguay.....	.....	24,048	24,048	.11%	1.6	1,667
Venezuela.....	444	8,737	9,181	.04%	0.4	285
Other Places.....	2,133	.....	2,133	.01%	0.5	235
Total.....	5,337	300,972	306,309	1.38%	0.5	19,359
ASIA:						
British India (March 31, 1922)....	12,399	23,958	36,357	.17%	0.01	2,089
China*.....	59,390	24,046	83,436	.38%	0.03	8,976
Japan.....	425,037	.....	425,037	1.94%	0.8	54,000*
Other Places in Asia*.....	54,585	5,844	60,429	.27%	0.05	6,109
Total.....	551,411	53,848	605,259	2.76%	0.1	71,174
AFRICA:						
Egypt.....	25,185	.....	25,185	.11%	0.2	2,905
Union of South Africa\$.....	56,081	.....	56,081	.26%	0.8	4,679
Other Places in Africa*.....	44,933	1,130	46,063	.21%	0.04	17,539
Total.....	126,199	1,130	127,329	.58%	0.1	25,123
OCEANIA:						
Australia (June 30, 1921).....	240,507	.....	240,507	1.10%	4.4	16,507
Dutch East Indies.....	34,936	1,905	36,841	.17%	0.1	2,337
Hawaii.....	.....	15,124	15,124	.07%	5.6	748
New Zealand (March 31, 1922)...	94,683	.....	94,683	.43%	7.6	6,244
Philippine Islands*.....	2,110	11,420	13,530	.06%	0.1	1,079
Other Places in Oceania*.....	2,000	370	2,370	.01%	0.1	60
Total.....	374,236	28,819	403,055	1.84%	0.6	26,975
TOTAL WORLD.....	6,313,768	15,635,192	21,948,960	100.00%	1.3	1,083,409

§March 31, 1922.

*Partly estimated. †Minus sign preceding a figure denotes decrease

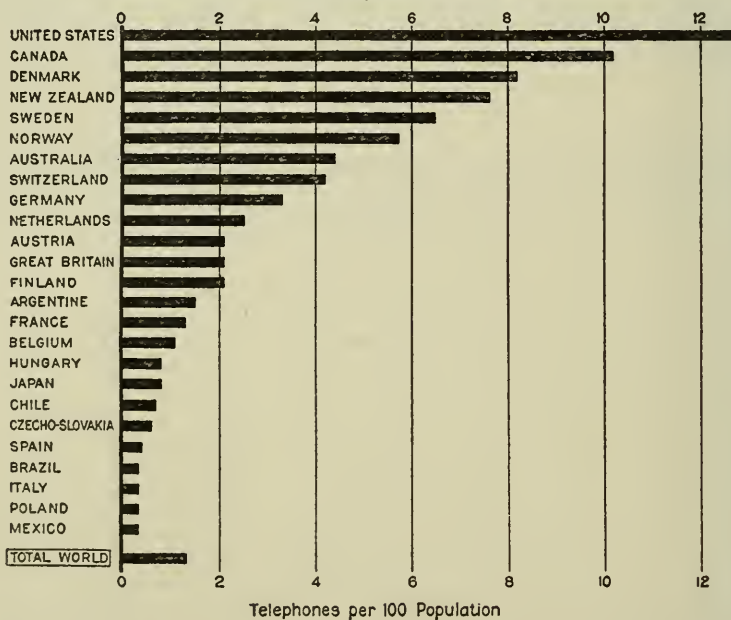
DISTRIBUTION OF THE WORLD'S TELEPHONES

— January 1, 1922 —

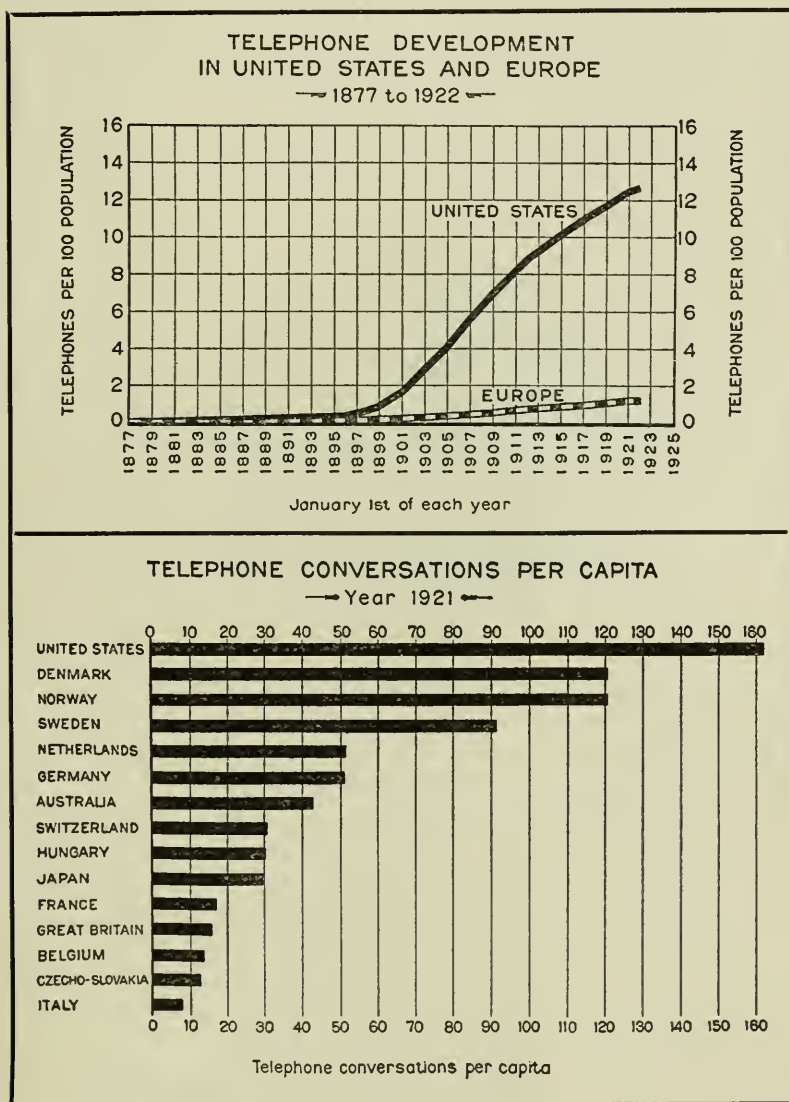


TELEPHONES PER 100 POPULATION

— January 1, 1922 —



but 1.2 telephones per 100 population, as against 12.7 in the United States on the same date. The relative



number of telephones in Europe today is no greater than that which existed in the United States in 1900.

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES IN IMPORTANT COUNTRIES, JANUARY 1, 1922

Country	Service Operated by (See Note)	Number of Telephones		Telephones per 100 Population	
		In Communities of 100,000 Population and over	In Communities of less than 100,000 Population	In Communities of 100,000 Population and over	In Communities of less than 100,000 Population
Australia.....	G.	152,288	97,204*	6.4	3.1
Austria.....	G.	94,800	37,500	4.7	0.8
Belgium.....	G.	54,010	26,499	2.5	0.5
Canada.....	P. G.	318,599	583,491	15.2	8.6
Czecho-Slovakia.....	G.	26,626	55,327	3.0	0.4
Denmark.....	P. G.	106,105	159,946*	14.8	6.2
France.....	G.	251,316	261,991	4.1	0.8
Germany.....	G.	1,039,778	905,823*	6.9	2.1
Great Britain and Ireland.....	G.	752,446	260,308	3.2	1.1
Hungary.....	G.	256,058	18,339	3.9	0.3
Japan.....	G.	44,161	168,979	3.5	0.3
Netherlands.....	G.	88,660	87,364	5.2	1.7
New Zealand (March 31, 1922).....	G.	30,348	64,335	8.0	7.4
Norway (June 30, 1921).....	P. G.	30,356	121,986	11.8	5.0
Russia.....	G.	102,441	68,300	3.4	0.1
Sweden.....	G.	144,942	240,661	20.8†	4.6
Switzerland.....	G.	57,566	104,139	9.9	3.1
United States.....	P.	5,725,902	8,149,281	16.5	11.0

Note: P. indicates telephone service operated by private companies, G. by the Government, and P. G. by both private companies and the Government.

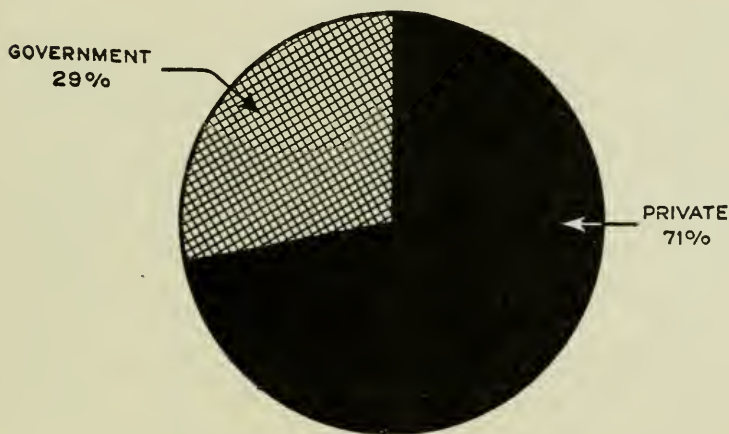
†The majority of this development is due to Stockholm. See note on Stockholm in table of Telephone Development of Important Cities.

*Partly estimated

Among the individual European countries, the relative extent of telephone facilities continues to be the greatest in Denmark, where the service is conducted almost wholly by private companies. The number of telephones per 100 population (8.2) in Denmark is, as a matter of fact, exceeded only by that in the United States and

OWNERSHIP OF THE WORLD'S TELEPHONES

→ January 1, 1922 ←



Canada of all the countries in the world. It is interesting to note that during 1921 Germany showed a net gain of 136,027 telephones, as compared with a gain of 40,095 in France and only 11,841 in Great Britain. At the beginning of 1922, Germany had 3.3 telephones per 100 population, as compared with 2.1 in Great Britain and 1.3 in France. The predominance of the United States in telephone communication is indicated by the fact that, relative to population, this country has about four times as many telephones as Germany, about six times as many as Great Britain, and about ten times as many as France. Another interesting fact shown by this table is that Russia, on the basis of the first official figures received since before the war, had only 0.1 telephone per 100 population. Moreover, the total of 170,741 telephones in Russia is

TELEPHONE DEVELOPMENT OF IMPORTANT CITIES, JANUARY 1, 1922

Country and City (or Exchange Area)	* Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINE:			
Buenos Aires	1,700,000	73,828	4.3
AUSTRALIA:			
Adelaide	261,000	17,022	6.5
Brisbane	218,000	13,202	6.1
Melbourne	795,000	50,777	6.4
Sydney	926,000	62,295	6.7
AUSTRIA:			
Gratz	158,000	4,800	3.0
Vienna	1,842,000	90,000	4.9
BELGIUM:			
Antwerp	469,000	12,565	2.7
Brussels	861,000	28,760	3.3
Charleroi	206,000	2,698	1.3
Ghent	279,000	3,740	1.3
Liège	300,000	6,247	2.1
CANADA:			
Montreal	840,000	83,917	10.0
Ottawa	159,000	24,996	15.7
Toronto	570,000	101,452	17.8
CHINA:			
Canton	900,000	2,475	0.3
Shanghai	1,500,000	16,466	1.1
Tientsin	800,000	6,631	0.8
Peking	1,300,000	30,000†	2.3
CUBA:			
Havana	456,000	27,318	6.0
CZECHO-SLOVAKIA:			
Prague	677,000	20,008	3.0
DANZIG, FREE CITY OF	357,000	12,957	3.6
DENMARK:			
Copenhagen	717,000	106,105	14.8
FRANCE:			
Bordeaux	267,000	8,285	3.1
Lille	201,000	5,281	2.6
Lyons	562,000	11,891	2.1
Marseilles	586,000	12,444	2.1
Paris	2,906,000	173,300	6.0
GERMANY:			
Berlin	3,804,000	347,735	9.1
Bremen	270,000	19,684	7.3
Breslau	528,000	27,736	5.3
Chemnitz	304,000	15,051	5.0
Cologne	634,000	38,666	6.1
Dresden	588,000	36,218	6.2
Düsseldorf	407,000	26,288	6.5
Essen	439,000	15,717	3.6
Frankfort-on-Main	433,000	37,705	8.7
Hamburg-Altona	1,155,000	95,534	8.3
Hannover	393,000	23,102	5.9
Leipzig	604,000	41,906	6.9
Magdeburg	286,000	14,654	5.1
Munich	631,000	46,214	7.3
Nuremberg	353,000	23,671	6.7
Stuttgart	309,000	26,211	8.5
GREAT BRITAIN AND IRELAND:*			
Belfast	414,000	9,168	2.2
Birmingham	1,286,000	27,615	2.1
Blackburn	252,000	4,972	2.0
Bolton	282,000	4,684	1.7
Bradford	379,000	12,118	3.2
Bristol	409,000	10,202	2.5
Dublin	391,000	11,294	2.9
Edinburgh	424,000	16,670	3.9
Glasgow	1,273,000	42,655	3.4
Hull	328,000	13,570	4.1
Leeds	541,000	13,287	2.5
Liverpool	1,202,000	38,895	3.2
London	7,139,000	341,498	4.8
Manchester	1,607,000	48,274	3.0
Newcastle	603,000	13,620	2.3
Nottingham	337,000	9,281	2.8
Plymouth	232,000	3,852	1.7
Sheffield	510,000	11,939	2.3

* Statistics as of March 31, 1922.

† Partly estimated.

TELEPHONE DEVELOPMENT OF IMPORTANT CITIES, JANUARY 1, 1922

(Concluded)

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
HUNGARY:			
Budapest.....	926,000	40,993	4.4
Szegedin.....	110,000	2,023	1.8
ITALY:†			
Florence.....	247,000	4,667	1.9
Genoa.....	299,000	7,999	2.7
Milan.....	701,000	16,944	2.4
Naples.....	770,000	6,344	0.8
Palermo.....	400,000	2,342	0.6
Rome.....	637,000	14,025	2.2
Turin.....	500,000	7,438	1.5
Venice.....	165,000	2,451	1.3
JAPAN:			
Kobe.....	637,000	18,725	2.9
Kyoto.....	613,000	17,786	2.9
Nagoya.....	617,000	15,008	2.4
Osaka.....	1,296,000	58,590	4.5
Tokio.....	2,304,000	103,524	4.5
Yokohama.....	431,000	12,380	2.9
JUGO-SLAVIA:			
Belgrade.....	112,000	2,937	2.6
NETHERLANDS:			
Amsterdam.....	689,000	32,931	4.8
The Hague.....	362,000	24,306	6.7
Rotterdam.....	524,000	26,057	5.0
NEW ZEALAND:*			
Auckland.....	161,000	10,678	6.6
Christchurch.....	107,000	8,265	7.7
Wellington.....	109,000	11,405	10.4
NORWAY:†			
Bergen.....	95,000	8,450	8.9
Christiania.....	258,000	30,356	11.8
ROUMANIA:			
Bucharest.....	350,000	8,600‡	2.5
RUSSIA:			
Kazan.....	246,000	1,126	0.5
Kharkov.....	474,000	5,008	1.1
Moscow.....	1,028,000	54,707	5.3
Odessa.....	565,000	1,600	0.3
Petrograd.....	706,000	40,000	5.7
SWEDEN:			
Göteborg.....	205,000	22,804	11.1
Malmö.....	114,000	12,043	10.6
Stockholm.....	377,000	110,095°	29.2°
SWITZERLAND			
Basel.....	136,000	12,179	9.0
Berne.....	105,000	10,205	9.8
Geneva.....	135,000	14,199	10.5
Zurich.....	207,000	20,983	10.1
UNITED STATES:			
New York.....	5,796,000	979,534	16.9
Chicago.....	2,808,000	605,495	21.6
Total of the 5 cities with over 1,000,000 population	13,170,000	2,317,830	17.6
Cleveland.....	966,000	153,951	15.9
Los Angeles.....	722,000	162,118	22.5
Total of the 12 cities with 500,000-1,000,000 popu- lation.....	8,239,000	1,322,036	16.0
Washington.....	449,000	96,111	21.4
Minneapolis.....	411,000	96,166	23.4
Denver.....	267,000	58,751	22.0
Total of the 16 cities with 250,000-500,000 popula- tion.....	5,105,000	928,175	18.2
Total of the 33 cities with over 250,000 population	26,514,000	4,568,041	17.2

* Statistics as of March 31, 1922.

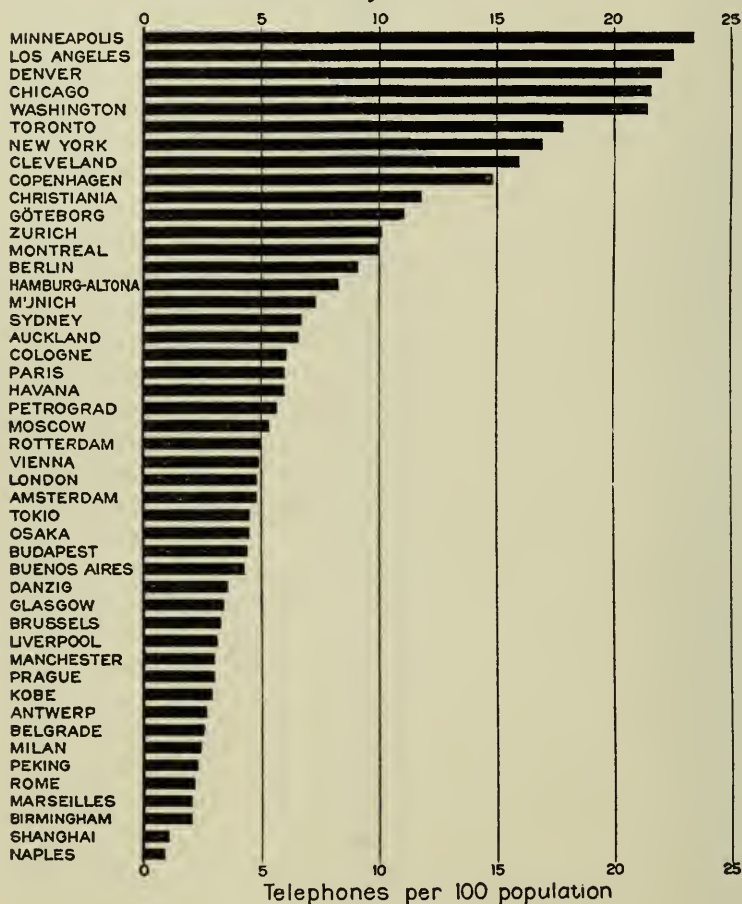
† Statistics as of June 30, 1921.

‡ Partly estimated

° The greater part of this development was secured by a private Company which was purchased by the Government in 1913. On January 1, 1922, the process of merging the private Company's plant with the Government's local system was not fully completed. Therefore the total number of telephones includes a certain number of duplicates.

TELEPHONES PER 100 POPULATION IN IMPORTANT CITIES

January 1, 1922



NOTE—This chart shows the comparative telephone development of the largest cities in the countries listed on the preceding pages. In the case of Sweden, however, the city of Göteborg is shown instead of the largest city, Stockholm, since the total number of telephones in Stockholm includes a certain number of duplicates with the result that its telephone development is not fully significant. Stockholm is, however, undoubtedly among the best developed cities in the world from a telephone standpoint. The United States cities shown include, in addition to New York and Chicago, a number of representative cities having a population between 250,000 and 1,000,000.

less than the number in that country at the close of 1913. Even allowing for the reduction in the number of telephones resulting from loss of territory during the intervening years, there appears to have been no increase of consequence in Russia's telephone development.

The table on "Telephone Development of Large and Small Communities in Important Countries" indicates that the distribution of telephone facilities with respect to the size of communities is much more even in the United States than in any European country. It is generally noted in all foreign countries that the bulk of the telephone development is to be found in the larger communities, while less populous communities and especially rural districts are comparatively neglected. Notwithstanding this condition, however, the table on "Telephone Development of Important Cities" shows that in the matter of telephone service foreign cities are relatively little developed as compared with American standards. Outside the United States and Canada, it is exceptional for a city to have as many as 10 telephones per 100 population; in Great Britain, for example, no city had as many as 5 telephones per 100 population on January 1, 1922. On the other hand, the 33 cities in the United States which had a population of 250,000 or over on January 1, 1922 showed an average of 17.2 telephones for every 100 inhabitants. In point of absolute number of telephones, large cities in the United States not only have more telephones than foreign cities of comparable size, but even have more telephones than the whole of most foreign countries. For example, reference to this table and to the table on "Telephone Development of the World, by Countries" indicates that Chicago has more telephones than all of France and that Cleveland has more than all of Italy. On January 1, 1922, New York City had nearly as many telephones as Great Britain and Ireland, and today has more.

S. L. ANDREW.

Two Founders of the Bell System

Intimate impressions of Thomas Sanders and Gardiner Greene Hubbard gathered from historical and personal sources.

THOMAS SANDERS was standing in the large hall of "Birchbrow," his beautiful residence on the edge of Haverhill, Massachusetts, one early spring afternoon, looking at the fire in the great open fireplace and meditatively smoking a cigar. A striking figure, erect, and a handsome man. With any one his keen black eyes first commanded attention, moving quickly here and there above his spreading black full beard. He always wore good clothes, and he wore them well.

One of his boys was looking out of the drawing room window down the hill toward the lake, around the shore of which the driveway swept up to the house. "What is that?" the youngster called out. "What is it?" his father asked without moving or stopping smoking. "A team with a lot of men. And another." Mr. Sanders went leisurely into the drawing room and over to the window. Around the curve of the hill down by the lake came one by one a string of wagons, four of them, every one of them loaded with men. There were something like sixty-five men in all, and all of them in red. "There's Uncle Charlie, hanging on to the last one!" exclaimed the boy. The two went out onto the verandah and stood at the top of the broad flight of steps that led up to the front door, waiting to see what it was, who they were, coming in red uniforms, with his brother bringing up the rear of the procession like the conductor of a line of busses.

As the last wagon drove up to the house and stopped, Charles Sanders sang out, "Here they are, Tom! I've come to pay my bet." A loud, hearty, delighted laugh was Mr. Sanders' reply, as in a flash he remembered the bet and understood the whole affair. A long time before

he had tried to get his brother to take some stock in the telephone company. But Charles Sanders had grave doubts of the future of the enterprise; it was altogether too risky. In fact all the rest of the family succumbed to Thomas Sanders' persuasions before he did. So as a final argument Thomas Sanders had come back at his brother with what was to them the supreme challenge, "If that stock does not go over par, I will hire the whole Salem Cadet Band, bring them to your place, and give you the finest band concert you ever heard in your life!" The two brothers were as crazy over bands as two small boys, and would often drive far out of their way to follow a good band in the street. And the Salem Cadet Band! Even the Boston Cadets would freely acknowledge that the Salem Cadet Band was the best in all the region north of Boston. "And if it does," Charles took his brother up, "I will bring them to Haverhill and give you a concert. And I will buy the stock to boot!"

In due time the stock went up over par. No burden of obligation weighed upon his mind, so Thomas Sanders forgot all about the concert due him. But Charles had not forgotten. It was a great concert that was given up there on the hill out under the trees. Thomas Sanders telephoned for a lot of friends, and sent carriages and teams and the busses for a good many of them. Everyone had a jolly time. After the first number, Thomas Sanders called for a favorite tune, and then Charles called for one; and so on. They kept it up far into the evening. The players might have been exhausted, but the story goes that they were not. Thomas Sanders supplied refreshments, and plenty of them. He was a generous man. The opening to his pocket was large. And this was in the early days.

This was the man who financed the early experiments that led up to the invention of the telephone. A leather merchant and man of means, he put in \$110,000, a large sum in those days, before he got back a cent of it. The story comes from a close friend of Mr. Sanders and from

a son, the boy who was looking out of the window. It is entirely characteristic of the man. But though genial and gay of spirit, Mr. Sanders knew trouble, and it was through trouble that Thomas Sanders came in contact with Alexander Graham Bell.

FIRST MEETING OF SANDERS AND BELL

Thomas Sanders' oldest child was born deaf. It seemed certain that the little fellow must go through life isolated. The sign language for the deaf made communications possible, but only to a limited extent, for the deaf could thereby converse only with those who knew the language—that is, other deaf persons, teachers of the deaf, and a few others. Usually even from their own families the deaf were practically isolated. It was a lonely life. The little Sanders boy had grown to be four or five years old; his education ought to be beginning.

About this time Mr. Sanders heard that Boston had in its public school system a day school specially for deaf children, where lip-reading was taught. By this method the deaf could “hear” by watching the lips of anyone speaking to them and in turn could learn to speak intelligibly. This method was taught but little in America. The teachers of the deaf most of them considered it waste of time. The chief advocate of the lip-reading method was a Mr. Hubbard, who lived in Cambridge, a lawyer and member of the Massachusetts State Board of Education. Further, there was at this school for the deaf a young teacher, about 27 years old, who had a special way of teaching lip-reading which was of very great advantage; the pupil learned faster and the results were much better. He called his method “Visible Speech”; it had been invented by his father. The young teacher's name was Bell.

It was not long before Mr. Sanders had looked into the whole matter. He met Mr. Bell, a tall young man, devoted to his pupils and to his work for them. His face was one not easy to forget. His complexion was very

pale, contrasting strongly with his black wavy hair, moustache and side whiskers, and unusually dark eyes, whose expression was quiet and dreamy but sometimes piercing and enthusiastic. After careful consideration Mr. Sanders decided that this young man was the one to teach his boy. Never doing anything half-way, he arranged for Mr. Bell to take little George as a private pupil in Boston. Then as it was not practicable for the child to live in Boston, and as it was not practicable for Mr. Bell to come to Haverhill, it was arranged that from October 1, 1873 on, the child was to live in Salem with his grandmother, Thomas Sanders' mother, and that Mr. Bell was to live there too, going to Boston whenever necessary for his classes in town. Mr. Sanders also found that Mr. Bell had a secondary interest, a hobby, of experimenting with electrical apparatus, that he was indeed something of an inventor, or hoped to be. So it was further arranged that he should have the attic of the Sanders house in Salem for his workshop, to experiment in.

The private tutoring was a great success. Bell did wonders for the boy. Mr. Sanders could not sufficiently express his gratitude. He sought for some way to show his appreciation. There was Bell's electrical experimenting. Unavoidably it ate up money. But it might lead to something after all. Mr. Bell, like many others, Elisha Gray included, thought he could invent a way of sending more than one message over a single telegraph wire at the same time. If he could, there would surely be money in it; the Western Union Telegraph Company would buy it up at once. Young Bell talked convincingly; and what he had actually accomplished seemed to be on the right track. Then too he had some ideas about a device for talking over a telegraph wire. Mr. Sanders did not see so much in that, but if Bell could make a success of it, it would be interesting at least. However, whether Bell's experimenting led to profitable results or not, Mr. Sanders felt deeply grateful, if not indebted, to him; and he liked Bell. Bell would certainly need a

good deal of money to complete his experiments, to take out his patents and to negotiate an advantageous sale of his inventions, as much as \$2,000 or \$3,000, and possibly it might run up to as much as \$5,000. But where could that young teacher of the deaf get so much money? He made up his mind what he would do. Then, too, who could tell, there might be money in Bell's ideas!

So in the fall of 1874 Thomas Sanders had a talk with Alexander Graham Bell and voluntarily made him an offer to supply him with whatever money he might need for his experiments, making payments from time to time on bills rendered, in return for a one-half interest in any inventions that might result.

Curiously enough, a few days later Gardiner G. Hubbard made a similar offer to Mr. Bell. Naturally Mr. Bell talked the whole matter over with both of his friends, and it was finally agreed that the three should form a partnership, in which Mr. Sanders and Mr. Hubbard should each undertake to supply half of what money should be needed in return for a third interest each in the resultant patents, if there were any.

It would be more correct to say that Mr. Hubbard came into contact with Alexander Graham Bell through his public spirit than through any misfortune, though in the main the story reads remarkably like that of Mr. Sanders. In the winter of 1861-1862 a severe attack of scarlet fever left Mr. Hubbard's little four year old daughter totally deaf. Following the advice of their friend, Dr. Samuel G. Howe, the parents turned away from the prevailing method of the sign language for the education of their little girl and started in to bring the child up in accordance with the principles of lip-reading. And in this they were notably successful.

HUBBARD'S INTEREST IN THE DEAF

Mr. Hubbard was instinctively a public spirited man. Even his own personal troubles he was habitually apt to think over in terms of the public welfare. When he

found that lip-reading was doing so much for his little Mabel, he accordingly began to consider what could be done to introduce the system widely into the education for the deaf in America.

He was a man of successful experience in advancing matters of civic improvement. Already in 1853 through his efforts and leadership illuminating gas had been introduced into Cambridge and the streets lighted. In 1855, chiefly through him, the Cambridge Water Works was organized and the town was given a reliable supply of pure water. In 1856 the first street railway, except in New York City, was opened as a result of his work between Cambridge and Boston. So again in 1864 he started a campaign to secure from the Massachusetts Legislature a charter for an institution for the education of the deaf where the lip-reading method should be introduced and with it an appropriation of \$5,000 a year toward its support. Finally, in 1867 the charter was secured and the Clarke Institution for Deaf-Mutes at Northampton was organized. In 1869, through the efforts of Mr. Hubbard and of the Rev. Dexter S. King, a member of the Boston School Board, a day school for the deaf, later called the Horace Mann School, was started in the Boston public school system, with Miss Sarah Fuller in charge as principal. So Mr. Hubbard had been actively working for the deaf for at least seven years before Mr. Bell came to Boston.

In the fall of 1868, Professor Alexander Melville Bell, Alexander Graham Bell's father, gave a series of lectures in the courses of the Lowell Institute at Boston. In these lectures Professor Bell spoke of what had been done for deaf children by means of his Visible Speech in London. Miss Fuller was present at these lectures. In 1870 Professor Bell lectured under the Lowell Institute again. Miss Fuller had now become principal of the school for the deaf, so as Professor Bell was to be in Boston for six weeks, she asked him if he could not come to her school and instruct her teachers in the use of Visible Speech in

the education of the deaf. His engagements prevented his doing this, but he said that his son, Graham, could doubtless come to Boston, and that as it was Graham who had introduced Visible Speech into the school for the deaf children in London, he could do the same in Boston. Miss Fuller then immediately went to Mr. Hubbard and Mr. King. They at once took hold of the matter energetically and in consequence in April 1871, Alexander Graham Bell took up his duties in the Boston School for the Deaf at 11 Pemberton Square, and started in on his life career as one of the greatest teachers and friends of the deaf in America. It was in this way that Gardiner Greene Hubbard came to know Alexander Graham Bell. The two at once became closely associated with each other in this work.

Meantime little Mabel Hubbard had made wonderful progress in lip-reading. By the time she was nine years old she could speak freely and was in every way the equal in education of children of her own age who could hear. In May, 1870, she was taken abroad, to Germany, the headquarters of the lip-reading school of education, and continued to progress until she was markedly proficient. She did not return to America until the fall of 1874.

FORMATION OF "BELL PATENT ASSOCIATION"

By the fall of 1874 Gardiner Greene Hubbard had known the young teacher for more than three years. Bell had been in the habit of going to the Hubbard house in Cambridge frequently. Mr. Hubbard knew all of Bell's interests. He knew about his electrical experimenting. He perceived promise of very practical commercial value in Bell's ideas for sending two or more messages over a single telegraph wire at the same time. Since 1867 Mr. Hubbard had been giving much time and attention to the study of the postal and the telegraph systems and to urging many practical improvements in those services. Accordingly he was specially interested

in Bell's ideas for a multiple telegraph and specially competent to form an opinion of their value. He thought the matter over very carefully and then made to Bell of his own accord an offer to undertake to supply the money necessary for his electrical experiments if Bell would give him in return a one-half interest in his inventions. He learned that the father of one of Bell's private pupils, Mr. Thomas Sanders of Haverhill, had a short time before made him practically the same proposition. So the three got together and formed an informal partnership, as before stated. About four months later, when Bell's first harmonic telegraph invention was ready for submission to the Patent Office, an agreement was drawn up between them, dated February 27, 1875, putting the understanding in writing. This has elsewhere been called the "Bell Patent Association."*

Hardly could two men have been more unlike than Gardiner Hubbard and Thomas Sanders. Mr. Sanders was a regular business man, well-known to be conservative in his attitude toward financial matters, but a lavish friend and a free spender. His striking personality expressed itself in his clothes. They always had an air of cheery sensation about them without being quite sensational. One suit was a small black and white check, with which he wore a flaming orange tie of plain silk. Indeed one clothing store in Haverhill used to save out any suit or overcoat that was too striking to sell easily and the proprietor would say, "Oh, lay that aside; I will sell it to Tom Sanders." and as a matter of fact Mr. Sanders usually did buy it sooner or later. Mr. Sanders enjoyed his clothes thoroughly.

CONTRASTED PERSONALITIES OF SANDERS AND HUBBARD

Mr. Hubbard was a lawyer, shrewd and cautious, yet far-sighted and perhaps somewhat visionary. At heart he was a civic promotor utterly intent upon the causes

*See *Bell Telephone Quarterly*, July, 1923. W. C. Langdon: The Early Corporate Development of the Telephone, on pages 134-135.

on which he had set his mind. Some called him close in money matters, though at the same time declaring him a most lovable man. But he was not at this time at all a man of means. He paid no attention to his clothes. They were comfortable; at least he was. Nor did any one else pay any attention to them. Probably the reputed "closeness" was the result of his indifference to money compared to the end he had in mind. This often put him into tight corners and made him count the pennies one by one between times scrupulously.

For example, in 1877 he considered it important for him and Mr. Watson to go to Altoona, Pennsylvania, to install an experimental telephone line for the Pennsylvania Railroad. Money was scarce. But to get there and to make the installation was the only thing that counted in Mr. Hubbard's mind. So he went and took Mr. Watson with him. It has been said, however, that he had to borrow from someone in Altoona the money to get back to Philadelphia, and from Mr. Thomas E. Cornish the money to get back to Boston. Nonetheless he had accomplished the important thing. Any inconvenience to himself, or to others, was a negligible matter.

Working in this spirit, seeing far ahead with the eye of his imagination and keen judgment in public affairs, it is easy to understand how he set himself in the 50's to bring about the needed improvements in his city, quite irrespective of the personal question of whether he could afford to give the time from his profession or not. Visionary? Yes, but also most practical—for the benefit of others, though not for himself. One great thing he knew and went boldly ahead on the knowledge of it,—that imagination is more often lacking than money; supply the imagination and the necessary money is easily found.

So life must have seemed to Gardiner Greene Hubbard an unrelenting scrutiny of the horizon for civic possibilities, sighting an object afar off, and step by step with untiring shrewdness, miserly of his attention to other things or even to his own other interests, regardless of other people's

opinions or convenience, working toward his object, stalking it, weaving a net around it, until he had it secured for the community.

For Thomas Sanders life passed from one exhilarating moment to another with longer or briefer intervals between the high points. To feel the whole ecstatic thrill of life, summed up in one intense joyful instant, that was the thing! A friend of his said that Thomas Sanders was very fond of horses, but after all, he thought, probably more for the sake of the races than for the sake of the horses. To see the winning horse come in across the line, neck outstretched, staring eyes, open nostrils, bandaged hoofs in a rapid rat-tat-tat pounding the track, a beautiful piece of horse-flesh in perfect form flashing across the line, with the second just behind,—that was a moment of pure complete life itself! To lead up to that,—what work, money, endless training, patient waiting,—what was not worth while!

So too in more serious, more important things, failure and loss with Thomas Sanders were quickly forgotten. To attain, to win out, and the joy of it, was the only thing that occupied his mind, before or after. To illustrate: Leather, the telephone, and silver were the chief financial interests of his life. One time a complaint was made of him that he had lost three great fortunes. It came to his ears. His comment to his wife was simply that it might be true, but what of it? it was not every fool that could make three great fortunes to lose.

SANDERS' UNWAVERING LOYALTY TO BELL

So in personal affairs and friendship. Thomas Sanders had given the young tutor to understand that he would financially stand back of his electrical experiments. True, he had undertaken to meet only half of the expenses, but Mr. Hubbard had proved unable to make good his half, and his original offer had been to take care of the whole. True, the amount was running far beyond any figure of which he had ever dreamed: \$5,000 had been

but a drop in the bucket; \$10,000 was gone; \$25,000; \$50,000 was disappearing. Mr. Sanders put in not only all his available cash, but mortgaged his property and staked his credit. He lost his reputation as a safe and conservative investor. One day his banker met him on the street and asked him to oblige him by taking his telephone paper out of the bank, as the inspector was coming the next day and he did not like to be caught with it on his hands. But all this made no difference to Mr. Sanders, so far as any one could see. For with Thomas Sanders, once a friend, always a friend. He would see it through, whatever happened. And he did believe in it—the telephone. He would bet on it; he had, heavily! He may have worried, but if so, the only way he showed it was with a laugh. So it was that he sank \$110,000 in the telephone, for the experiments, for securing the patents, and for starting the business—twice as much as his promise had required, and twenty times as much as he had originally thought of doing,—before he got a dollar back.

But if Mr. Hubbard was not able to put in his half of the money for the financing of the telephone, he did quite as much in his own way and true to his own character. The early development of the telephone was not a mere matter of routine daily duties. There was much human friction, as must needs be with such genuine individualities as the group of men who had gathered together for its service. Deliciously characteristic was a little contretemps between Mr. Hubbard and Mr. Sanders at the time when Mr. Hubbard as Trustee of the Bell Telephone Company had the entire control in his hands and when Mr. Sanders was Treasurer. Mr. Sanders once went so far, under special provocation, as to complain to Mr. Hubbard of the serene way he went ahead incurring obligations when the treasury was empty and he could only with great difficulty find money for the pay-roll. Mr. Hubbard came back with a rebuke to Mr. Sanders for blindness of vision that he could not see the glorious

future of the telephone and added that it was the part of the treasurer to find the money, not to get discouraged. And Mr. Hubbard was right, judged from his own standpoint. They were both right, each in his own position. But their positions were different!

It was by the same arbitrary wisdom that Mr. Hubbard took matters into his own hands and directed Anthony Pollok, the patent attorney, to go ahead and file the application for the first telephone patent without saying anything about it to Mr. Bell. This saved the patent, it may be, by just two hours. So also it was entirely to Mr. Hubbard's credit, as Dr. Bell himself said, that the telephone was exhibited at the Centennial in Philadelphia in 1876, and at that exceptionally advantageous time introduced to the scientific world in the persons of Joseph Henry, Sir William Thomson, and the eminent amateur scientist, Dom Pedro, Emperor of Brazil.

It has been said that Mr. Hubbard did not at first appreciate Alexander Graham Bell. This is far from true. Mr. Hubbard was too shrewd and far-seeing in his knowledge of men not to recognize and accurately appraise the value of the young man who for five years was continually thrown with him in work for the welfare of the deaf. He appreciated young Bell as a true-gauged, human-hearted soul; he appreciated him no less as an inventive genius. He also appreciated him as one who was quite innocent of any ability for business or liking for the same. When Miss Mabel Hubbard at the age of seventeen returned to America, Mr. Bell met her at her father's house and the young people saw much of each other in the family circle. While she may have taken a few lessons from Mr. Bell, in order to get acquainted with the principles of Visible Speech, Miss Hubbard cannot correctly be said to have been a pupil of his. But Mr. Bell was always welcome at the house, as before, and the acquaintance grew into friendship and love.

When the question of the young people marrying

came up, however, Mr. Hubbard was first of all a father. His love and solicitude for his daughter brought all his native caution to the front. His attitude was not the less appreciative of the fine young suitor, in that he recognized that as a provider for a wife and children Bell's absolute lack of business ability had become the most serious fact in the situation. It was for this right and most natural reason that he earnestly encouraged, and maybe suggested, the idea that at their marriage Bell should make over to his bride practically all his telephone interests, with himself, Mr. Hubbard, as her guardian. It was wise for both their sakes, and by this arrangement Dr. Bell was all his life relieved from this kind of responsibility and his mind freed for other things.

BEGINNING OF POLICY OF SELLING SERVICE AND NOT INSTRUMENTS

The greatest thing that Gardiner Greene Hubbard did in his administration of the telephone was establishing the business policy of the telephone on the principle of renting telephones and not selling them. As attorney for the Gordon MacKay Shoe Machinery Company he saw that principle in practice. He realized that it was the wisest principle on which to build up the telephone business. As he was Trustee he was able to adopt it without gaining first the consent of anyone, and he held to it persistently against both the severe pressure of lack of money and the united opposition of all the others concerned. Even Mrs. Hubbard, his own wife, at one time went to Mr. Watson in the shop to beg him to join them and to add what influence he might have with Mr. Hubbard to persuade him to sell telephones instead of renting them, so much more money would be received in that way and they needed money so badly. But Mr. Hubbard stood firm. He had the power and nothing could move him from the policy. And the whole business structure of the Bell System is built upon his position; if he had yielded, it could not have been. The

renting of telephones led to the licensing system, and the licensing system led to the sale of service only. This indifference to money, so characteristic of him, was the concomitant of his far-sighted wisdom and his determination to bring the right thing about.

Thomas Sanders and Gardiner Greene Hubbard! They were real men. Truly there were giants in those days, as well as now, and these giants were not a bit alike. They were extreme in their difference from each other. There is much to justify the generalization that fundamentally Gardiner Greene Hubbard was in the conditions of his time and in fact a radical, and that Thomas Sanders was a conservative, despite all that comes to mind to the contrary. This is signally illustrated in the men to whom they gave way. It was the conservative Thomas Sanders that compelled the evacuation, taking his own departure with it. There is a letter he wrote to Mr. Hubbard in which he plainly stated that in order to interest the money necessary for the further development of the telephone business both of them, Mr. Sanders and Mr. Hubbard, must yield the control of the board to new men. Through Thomas Sanders there came into telephone affairs George L. Bradley and Charles M. Bradley, and through them came in the old, conservative, financially solid Boston family of the Forbes, in the person of William H. Forbes. Old John Murray Forbes of the East India trade said No, he would not go into anything new, but he had no objection to Will's taking hold of the telephone if he wanted to. So William H. Forbes, the son of John Murray Forbes and the son-in-law of Ralph Waldo Emerson, became the President of the National Bell Telephone Company in March, 1879.

But if from the point of view of the Boston of the 70's and 80's Gardiner Greene Hubbard was a radical and Thomas Sanders was a conservative, that kind of radicalism was not outdone and ended by the accession of the Forbes interests. A year before, Mr. Hubbard

had laid eyes on a man in the United States Railway Mail Service in Washington. He made up his mind that that was the man to develop the telephone as a business. Although Mr. Hubbard frankly told the man that he could not guarantee payment of the salary of \$3,000 a year offered him as General Manager of the Bell Company, the man accepted, "only asking in addition a reasonable assurance of permanency." For Theodore N. Vail was a man of vision no less than Gardiner G. Hubbard, and he saw the validity of Mr. Hubbard's visions. Far-seeing, abrupt, masterly, he too could see to the horizon, and fortunately he could always find the money too.

Truly, as is often the case, with Thomas Sanders and Gardiner Greene Hubbard, their greatest services were not what they themselves did, but what they did for the continuance of the work after them. Thomas Sanders brought in William H. Forbes, and Gardiner Greene Hubbard brought in Theodore N. Vail. These two, working together, took the telephone from Sanders and Hubbard in New England and made it a national institution.

W. C. LANGDON.

Abstracts of Recent Technical Papers from Bell System Sources

Permalloy, a New Magnetic Material of Very High Permeability,¹ by H. D. Arnold and G. W. Elmen. The magnetic alloy described in this paper is a composition of about 78.5% nickel and 21.5% iron and at magnetizing fields in the neighborhood of .04 gauss and with proper treatment has a permeability running as high as 90,000. This is about 200 times as great as the permeability of the best iron for these low magnetizing fields. This high permeability is attendant upon proper heat treatment and also upon other factors among which is freedom from elastic strain. The presence of other elements than iron or nickel and specially carbon, reduces the permeability, but slight variations in heat treatment produce large changes compared with those due to small quantities of impurities.

So far as discovered, other physical properties show no peculiarities at the composition which brings out the remarkable magnetic properties of permalloy. The equilibrium diagram, electric conductivity, crystal structure, mean spacing between adjacent atom centers and density are among the physical properties which have been studied.

To the engineer in electrical communication the development of permalloy is very significant. It assures a revolutionary change in submarine cable construction and operation and promises equally important advances in many other fields.

The Crystal Structure of Quartz,² by L. W. McKeehan. Photographs by the powder method of X-ray crystal analysis have confirmed the space-lattice proposed for quartz by the Braggs and others. A careful study of 30 possible arrangements has shown that the arrangement

¹Published in the Journal of the Franklin Institute, May, 1923; also in the Bell System Technical Journal, July, 1923.

²Physical Review, Vol. 21, pp. 503-508, May, 1923.

of atoms which best accounts for the observed intensities of the lines in the photographs differs somewhat from those previously proposed, maintaining more clearly the identity of the molecule SiO_2 . These molecules appear therefore to be obtuse-angled isosceles triangles the angle at the silicon atom-center being $115^\circ.2$, and the distance between silicon and oxygen atom-centers being 1.631×10^{-8} cm. These molecules lie flat in the basal planes of three interpenetrating hexagonal space-lattices, so that the crystal may be considered as built up of layers of molecules, much closer together than are the adjacent molecules in each layer.

Telephone Equipment for Long Cable Circuits,³ by Charles S. Demarest. This paper describes some of the important developments in telephone apparatus and equipment which have been brought about by the engineering of long toll cables. The large number of equipment units per station in the cable plant and the greater number of stations in a given length of cable than in an open-wire system have made the economic importance of the equipment design such that a comprehensive program of development, affecting many types of equipment, has been undertaken. The outstanding features of some of the more important of these, including the telephone repeater equipment, test board equipment and signaling equipment, are described. The necessity for compactness in the dimensions of equipment units, uniformity in assembly arrangements, and simplicity in design, together with the need of careful correlation of the electrical and mechanical requirements, are emphasized. The methods proposed for meeting these requirements, generally, are described.

A Determination of the Coefficient of Slip of Surfaces in Air,⁴ by Leland Johnson Stacy. In 1860, Maxwell, while working on the mathematical theory of gases, obtained an expression for the coefficient of viscosity

³Presented before A. I. E. E., June 27, 1923. Published in the Bell System Technical Journal, Vol. II, July, 1923.

⁴Physical Review, March, 1923.

which was independent of pressure. This paradoxical result was found to be true except for low pressures. It was subsequently shown that this discrepancy was due to the gas slipping along the surface of the apparatus used in measuring viscosity. The author has measured this coefficient of slip for both rough and smooth surfaces. He has used a constant deflection method by which a hollow rotating cylinder produces a torque on a smaller stationary concentric cylinder by virtue of the viscosity of the gas between the two. From a knowledge of the torque, speed and the dimensions of the cylinders, the coefficient of viscosity can be computed. The coefficient of slip can be determined from the values of viscosity at two pressures. The results for shellac surfaces are in close agreement with those obtained from the correction to Stokes law obtained from falling shellac drops.

The Scattering of Electrons by Positive Nuclei,⁵ by C. Davisson. The simple theory of atomic scattering developed by Rutherford and verified by Geiger and Marsden is given and discussed. This is then extended by assuming that the mass of the electron varies with velocity in accordance with the relativity mechanics. This results in distribution patterns which depart considerably from those computed by the simple theory. Semi-graphical methods are developed for constructing such distribution curves. When a second extension is made by taking account of the mutual energy of the electrons and nucleus as suggested by H. A. Wilson, the scattering patterns conform more closely to those calculated from the simple theory.

Radio Extension of the Telephone System to Ships at Sea,⁶ by H. W. Nichols and Lloyd Espenschied. The paper describes the development of a two-way radio-telephone system and its use in extending the Bell Telephone System to connect with ships at sea. The elec-

⁵Physical Review, June, 1923.

⁶Presented before the Institute of Radio Engineers, New York, January 3, 1923. Reprinted in the Bell System Technical Journal, July, 1923, with minor changes from the Proc. of Institute of Radio Engineers, June, 1923.

trical considerations and the experimental work involved in determining the system-design of the radio link are discussed. Two land stations were established, one of them a permanent three-channel station on the New Jersey coast. Two coastal vessels and finally one trans-Atlantic liner were equipped. These installations are briefly described in the paper.

The operation of the combined radio and wire system is explained, particularly in respect to the transmission characteristics of the over-all system and the effect there-upon of the movement of the vessel and of variations in atmospheric conditions. Measurements of the variations in the field strength received from vessels at sea show why it is possible to receive over very long distances at favorable times at night and not during the day. The method of establishing combined radio-telephone-wire circuits to ships is described and representative results are given of the considerable telephone traffic which was handled over the system experimentally during a period of trial operation. Tests of multi-channel telephone operation to several ships through the Deal Beach shore station, and also tests of simultaneous telegraph and telephone operation from the same vessel are described. Connection of a vessel thru the trans-continental telephone line to the Catalina Island radio-telephone system, whereby the vessel in the Atlantic talked with an island in the Pacific, is briefly described, and finally the outstanding conclusions of the entire development work are given.

*Machine Switching Telephone System for Large Metropolitan Areas,*⁷ by E. B. Craft, L. F. Morehouse and H. P. Charlesworth. From the earliest forms of telephone switchboards to the modern types, the development of the switchboard has been marked by the increasing use of automatic methods to supplement the

⁷Bell System Technical Journal, Vol. II, April, 1923. Presented at the Mid-winter Convention of the A. I. E. E., Feb., 1923, and published in the Journal of A. I. E. E., Apr., 1923.

manual operation wherever this would result in better service to the public or more efficient operation.

In addition to all that has been done in developing and introducing automatic operations with manual switchboards, it has been found desirable and practicable to go further in the direction of introducing automatic operation in the telephone plant and a machine switching system has been developed in which the bulk of the connections are established without the aid of an operator.

The complexity of a large metropolitan area and the exacting requirements which a machine switching system must meet are outlined briefly, and the system which has been developed to meet these requirements is described.

The application of the system to a typical large metropolitan area and the means provided for permitting its gradual introduction into the existing plant are discussed.

Transient Oscillations in Electric Wave-Filters,^{*} by John R. Carson and Otto J. Zobel. This paper gives the results of theoretical study of the behavior of electric filters in the transient state. It is found that the remarkable selective characteristics of filters are peculiarly properties of the steady state and become sharply defined only as the steady state is approached. To this fact the authors ascribe the uniform failure of filters to suppress irregular and transient interference, such as the "static" encountered in radio communication, with anything like the degree with which they discriminate against the steady state currents lying outside the transmission range. This limitation is common to all types of selective networks and restricts the amount of protection it is possible to secure from transient interference. The general conclusions reached are applicable to all types of selective circuits.

The following are the main divisions of the paper:

1. The indicial admittances of a representative set of wave-filters.

^{*}Bell System Technical Journal, Vol. II, July, 1923.

2. The mode in which the steady-state is built up after a sinusoidal voltage within the frequency transmission range is applied to the wave-filter.

3. The character and duration of the transient current when a sinusoidal voltage outside the frequency transmission range is applied to the filter.

4. The energy which penetrates through selective circuits from random interference.

Use of Labor-Saving Apparatus in Outside Plant Construction Work,⁹ by J. N. Kirk. This paper completes a discussion, the first installment of which was reviewed in the BELL TELEPHONE QUARTERLY for April, 1923. The present article describes some of the more important applications of various types of labor-saving machinery to outside plant construction. Among the labor devices discussed are different types of derricks, trailers, earth-boring machines, air-compressors and compressed air tools. Figures are also given showing the savings resulting over manual methods of carrying out similar operations.

A Method of Graphical Analysis,¹⁰ by Helene C. Bateman. In connection with many telephone problems of an economic character, it is necessary to develop methods for making estimates and forecasts of the effects of changes in conditions. When the changes in conditions are such that direct experimentation is impracticable the development of logical methods and bases for estimates involves analyses of past experience in specific situations and, in so far as is feasible, the generalization of such experience. This paper describes briefly a graphical method by which complex economic data may be generalized for use in forecasting probable future conditions.

Simultaneous Color Measurements of Illuminants by Trichromatic and Monochromatic Analysis,¹¹ by Herbert E. Ives. This paper describes simultaneous measurements made by

⁹Bell System Technical Journal, Vol. II, July, 1923.

¹⁰Bell System Technical Journal, Vol. II, July, 1923.

¹¹Optical Society of America; vol. 4, No. 4, April, 1923.

two methods of color measurement, the trichromatic and the monochromatic. A previous paper by the same author* was devoted to developing the mathematical transformations necessary for expressing measurements made by one method in terms of the other. These transformation methods are based on rather meager experimental data and it was thought desirable to test by experiments, how accurately the actual transformations from one system to another might be made.

The different colors selected for measurement were a series of artificial illuminants and the measurements were carried out by means of a color match photometer previously described**, which permitted all the measurements to be made at the condition of color match.

The results of the measurements are given in tabular form. In general it is found that the agreement between the two methods, using the transformation equations and available data is not very satisfactory. The opinion which was expressed in the development of the transformation methods that new fundamental color mixture data should be obtained before reliance can be placed on the transformation methods is confirmed.

*Journal of the Franklin Institute, January, 1923, p. 23.

**Journal of the Optical Society, March, 1923.

Notes on Recent Occurrences

AN EXPRESSION FROM PRESIDENT HARDING

IT was the great privilege of the Bell System to provide for the late President on his trip to Alaska facilities for keeping in telephone communication with the national Capitol, and for addressing more easily and widely his fellow countrymen through the public address system and radio broadcasting.

We are all gratified that these arrangements lessened the burden of the Chief Executive's last few weeks of life.

A telegram sent by President Harding to H. B. Thayer, President of The American Telephone and Telegraph Company, from Salt Lake City shows that President Harding was not unmindful of these arrangements. In it he said, "I wish to express my great appreciation of the splendid service we have had through the electrical equipment of the Presidential train. I gather that it was more or less experimental from your viewpoint and as the chief beneficiary of it I desire you to know how vastly it has lessened the burdens of a difficult trip. When opportunity is afforded I wish to make a more adequate acknowledgement than this."

The Bell System engineers detailed to the Presidential train received a personal compliment in an invitation to accompany the President to Alaska. The telegram of invitation read as follows:

"The President would be very pleased if Messrs. Truesdell, Maloy and Santee of your Company could accompany the party to Alaska on the transport Henderson. Entire party feel deep obligation for their services and would be glad if you care to authorize them to take the trip. Reservations have been made for them subject to your approval of the trip. Thank you."

The engineers referred to are: J. G. Truesdell, Radio Broadcasting Department, American Telephone and

Telegraph Company; J. P. Maloy, Long Lines Department, American Telephone and Telegraph Company; H. B. Santee, Loud Speaker Department, Western Electric Company.

CATALINA RADIO TELEPHONE SYSTEM SUPERSEDED BY SUBMARINE CABLE

THE radio telephone system which for the past three years has connected the Island of Santa Catalina with the rest of the Bell Telephone System was closed down on August first. An enlarged service to the Island is now being given over two submarine telephone cables, which were laid to the Island a few weeks before the closing of the radio.

The passing of this radio system is of more than usual interest, both from an historical and a technical standpoint. It was the first, and so far as known, the only radio telephone system which has ever given a commercial telephone service, meeting in both transmission and signaling (although not as regards secrecy or economy) the ordinary requirements of wire telephone circuits.

The system was originally installed because, under the conditions at that time, it was the only form of communication which could be established to the Island without considerable delay. Its three years of reliable service, combined with the large volume of traffic handled over it, are an ample demonstration of the success with which the system met the requirements of commercial operation. When the time came, however, to enlarge the service to the Island, the radio system had to give way, as its annual charge was very much greater than that of a cable circuit of the type now employed.

The radio system, however, would have been kept in service for a few months longer as an extra circuit during the summer season if the governmental authorities supervising radio had not ordered the service termi-

nated, so that the wave lengths which it employed could be made available for broadcasting purposes. This matter of wave length was discussed in connection with the "Second National Radio Conference" in the *BELL TELEPHONE QUARTERLY* for April. The Catalina system operated on wave lengths between 300 and 500 meters. The advent of radio broadcasting has so greatly increased the demand for wave lengths that there appears to be no space in the ether for a service of this kind anywhere in the range of wave lengths which are now used practically.

It is to be expected that radio wave lengths considerably shorter than those now employed will be made commercially available in the future, and the question will then again arise as to whether radio can be made to economically take care of cases such as this in which it is necessary to bridge moderate length water gaps. There will still remain the difficulty, however, of putting the radio system on a sufficiently low annual charge to compare with submarine cable, and also it may be that the need for radio wave lengths, in order to care for services for which wires are not available, such as to moving vessels, airships and land vehicles, will have developed to such an extent by that time as to again leave no available wave lengths for situations such as this.

A paper on the construction and operation of the Catalina System was published in the *Proceedings of the Institute of Radio Engineers* for December, 1921. There are a number of technical matters in connection with the system which have not been generally appreciated, and which are worth mentioning here.

The system was provided with a duplex radio telegraph circuit superimposed upon the telephone circuit. In the telegraph circuit a 5,000 cycle current, broken up into dots and dashes, was combined with the voice currents, and together with them modulated upon the radio frequency carrier currents at the sending end. At the receiving end the telephone and telegraph were de-

tected together, and then separated out by electrical filters, taking advantage of their different frequencies.

As a result of using the "dispatch" method of operation over the circuit, something of a record for the handling of messages was made with it. On occasions over 200 conversations were completed over it within a single day.

The system of reception employed gave an unusually high degree of "selectivity," that is, ability to cut out interference from other stations. This was obtained by an "intermediate frequency" form of reception in which the incoming waves were "beaten" down in frequency to about 50,000 cycles, at which point they could be very sharply selected from other frequencies by the means of filter circuits. After filtering, the final detection and amplification of the signals was carried out.

Some six weeks before the radio was taken out of service, a "privacy" system was installed in connection with it. In this system the transmission was sent out in such form that the ordinary radio receiving sets could not pick up the messages and convert them into understandable speech. The system was not "secret" in the sense that one familiar with the methods used could not construct a set which could listen to it. Such a set, however, would be much more complicated than the ordinary set, and the added complication would be of no value except for picking up transmission over the system. It gave a degree of privacy, therefore, something comparable to that obtained by a lock and key, which may not prevent a property from being broken into, but which does, in general, furnish a high degree of privacy to it.

DR. H. W. NICHOLS
WINS FAHIE PREMIUM

DR. H. W. Nichols of the Western Electric Company, has been awarded the Fahie Premium by the Institute of Electrical Engineers of London for his recent

lecture, before the Institute, on transatlantic wireless telephony.

Dr. Nichols, who was one of the Company's representatives in London last January during the demonstration of transatlantic telephony, is in charge of wireless research in the Bell System Research laboratories.

DR. F. B. JEWETT ADDRESSES PACIFIC COAST
MEETING OF THE A. I. E. E.
FROM NEW YORK

ON October 4th, the Pacific Coast Convention of the American Institute of Electrical Engineers met in Del Monte, California, to confer the Edison Medal, and as President of the Institute at the time the award was made, it was the duty of Dr. F. B. Jewett to make the presentation speech. The medalist this year is Professor R. A. Millikan of the California Institute of Technology. As Dr. Jewett was unable to leave New York, arrangements were made to transmit his speech over the transcontinental telephone line. The Pacific Telephone and Telegraph Company installed loud speaking equipment at Del Monte so that the entire convention could hear the speech.

The Edison medal is the highest honor which the Institute of Electrical Engineers can confer and Dr. Jewett, in referring to the medalist, said in part:

"Although Professor Millikan's claim to recognition rests particularly on his experimental work, there are two other classes of achievement for which we here in America are greatly indebted to him. One of these is his work during the war and in the formation of the National Research Council, and the other is his influence as a producer of men."

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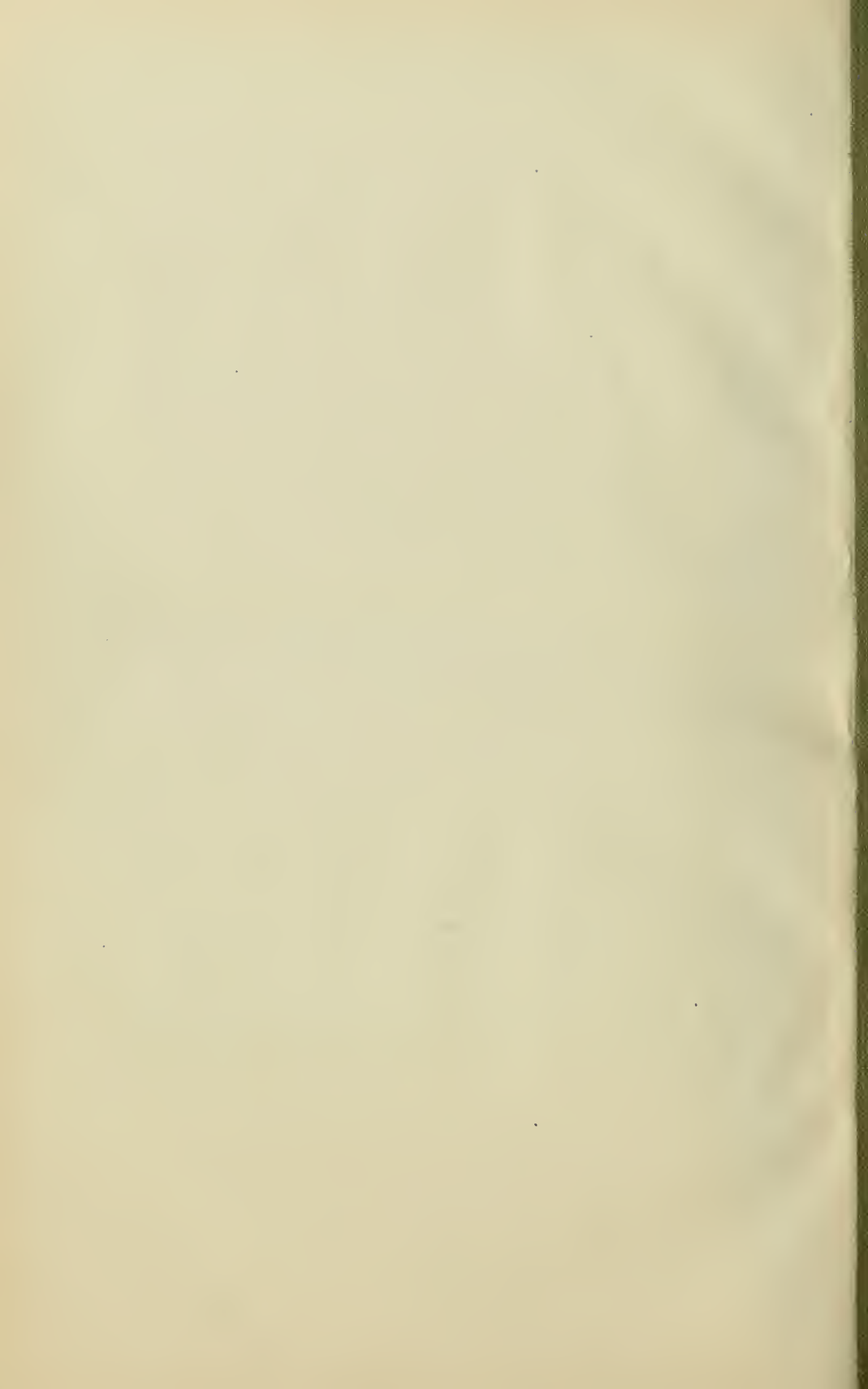
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